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MID-AIR OBSERVATIONS.

By JOHN M. BACON, F.R.A.S.

ON carefully comparing the notes made by my daughter and myself on the morning when the Leonid shower was expected to be in progress, a few points of scientific interest have been brought out which may be worth recording, although having but little bearing on astronomy. It may perhaps be claimed that their value should be all the greater from the fact that the circumstances of our position as aerial observers, compelled by a strange chance to remain aloft for many hours, enabled us to give mature and undivided attention to the few principal facts which I proceed to detail.

Our actual view of such Leonids as were visible was undoubtedly much enhanced by the exceptional advantage we enjoyed of riding at 4,000 feet above any ground surface, and, moreover, riding with the air currents. Sufficient proof of this lay in the fact that the stars from every quarter shone out of a black sky with a brilliance and definition never equalled in my experience, save on a former occasion when I made an equally elevated night voyage. The altitude of the radiant at the time of our ascent being about sixty degrees, the body of the Balloon would hide such meteors as shot upward, but, among those seen, one at least was remarkable for its long-lasting trail, while at another time a burst of three or four, darting in twisting courses towards Orion, presented a peculiar phenomenon such as I cannot recall, resembling a small discharge of tailed stars from a rocket head. The unusual and persistently blue colour of Sirius was very noteworthy. Though its hue constantly changed, it could never have been described as possessing any other colour than blue.

Still more remarkable however was the green-grey colour of the dawn. This shade was evanescent but for the while strikingly noticeable, and corresponded with such dawns as were much more pronounced and long-lasting at the period following the eruption of Krakatoa in 1883. It becomes a question whether, paucity of visible meteors notwithstanding, there may not have been some unusual proportion of cosmic debris intercepted by the upper strata of the atmosphere as the earth crossed the track of the main Leonid stream.

Though the official time of sunrise on this morning was not till 7.21, it was two or three minutes before six when with us the dawn began to break, and this with a rapidity which I have not seen surpassed even in India. To explain this latter phenomenon I would suggest a double cause. First, that low-lying matter and moisture in suspension, capable of reflecting and diffusing light (and thus of anticipating dawn), had in great measure been surmounted; and, secondly, that as soon as appreciable light appeared its intensity was redoubled by reflection off the brilliantly glistening snow-surface below us. The cloud-veil here spoken of had been first entered at an altitude of 1,500 feet, and proved to be some 1,600 feet in thickness, and its thermal conditions were sufficiently remarkable.

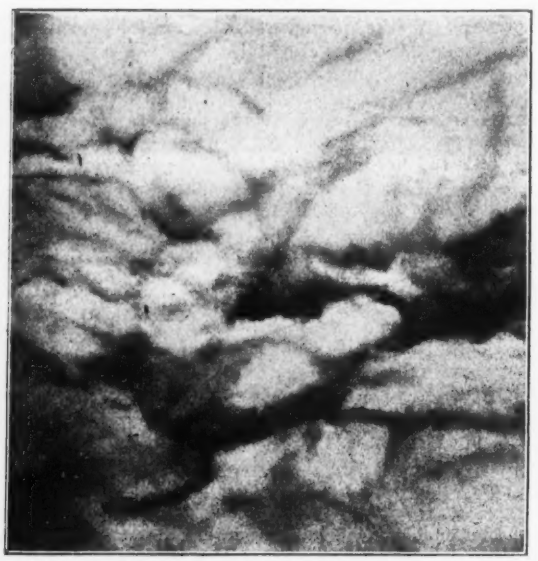
Owing to the rapidity of our ascent, the temperature of the lower levels was not accurately taken, but though when we left the ground the night was one of exceptional mildness for November, entering the cloud layer struck us like passing into a warm greenhouse atmosphere, and its temperature certainly cannot have been less than 50 degrees. The upper fringe of the same cloud, however, tested accurately by a sling thermometer, showed a temperature of 38 degrees, while at a full thousand feet above in the clear open sky the same thermometer showed a reading 4 degrees higher. The Balloon gathered an extraordinary weight of condensed moisture necessitating the discharge of many bags of ballast, and all objects about us became rapidly and densely dewed; yet, at the upper surface where billows of mist, mountains high, were surging and vanishing into space, evaporations must have been going forward very briskly, the super-incumbent air being doubtless comparatively dry. It was just at the wasting upper fringe of the cloud that the sensation (unusual in a free balloon) of constant draughts was experienced, and this experience was repeated whensoever we dropped or rose into this particular region.

For the first hour the balloon constantly rose and fell with a strongly marked pendulous motion, owing to its many struggles with the moist cloud-wreaths and the continual discharge of sand; but, oscillations once over, its perfect poise was remarkable and unexampled in my own experience. The region in which it then

floated was probably shielded from ascending currents by the cloud-floor, and in the hour before sunrise the upper levels had doubtless subsided into an exceedingly quiescent and homogeneous state.

The cloud-floor itself, or rather its upper face, was worthy of the close attention which we were ready to give it through many long hours. Speaking generally it seems to have passed through three distinct stages. First and earliest, it presented a fluffy cotton-wool appearance, or perhaps could be better described—at least when viewed from a thousand feet or more above it—as wearing the appearance of recently fallen snow, lying deep but light and feathery.

Later on this seeming snowfield, interminable in extent, appeared of harder surface and more compacted, like even snow when it has been subjected to bright winter sun for several days. Then in the end—as though to complete the analogy—these snow plains com-



1 p.m.—Cloud-floor as though thawing into hollows.

menced breaking up infinitely slowly, into black pits and hollows through which the actual earth, though several thousand feet below, began to show itself.

The trivial incident of our having suddenly found a big blue fly buzzing noisily about us, when hanging at a height of 8,000 feet, would have passed without serious notice but for certain correspondence which has since arisen. Mr. F. T. Wethered, of the Alpine Club, writes to say that he has seen a butterfly scudding across the summit of the Grandes Jorasses at a height of 13,799 feet, and sees no reason why the fly should not have been on the wing and not taken up in the car as we had supposed. M. C. Flammarion tells of white butterflies fluttering round his balloon at 3,280 feet, though in the same voyage he remarks on the silence of bird and insect life at sunrise. My own experience has always been that winged creatures of every kind have been left behind long before the first thousand feet were reached. The height at which the swift is flying is surmounted with the first leap into space, and even when sailing at the lowest levels compatible with safety the skylark is neither seen or heard; very possibly, however, all creatures of the air take alarm at a balloon and naturally give it a wide birth.

Sounds claimed our closest attention throughout our voyage, inasmuch as we were constantly straining our ears to determine whether we were over land or sea. The deep cloud-barrier below us certainly appeared conducive rather than inimical to the penetration of sound from earth. At almost our highest elevation the bark of a dog was caught, while the shrill challenge of many cocks reached nearly as high. The bellow of cattle was heard at upwards of 6,000 feet, the ringing of horses' hoofs on a hard road at a thousand feet lower, and at 4,000 feet the unmistakable splashing of ducks on water. The strangest case of great penetration however was afforded by the splash of waves on shore. I would submit that our ears were highly strung and abnormally sensitive to this sound, as being that which we most dreaded to hear.

One other sound of an uncanny nature there was that began to haunt us as we reached the loftier regions. Amid the dead silence we heard, fitfully, stealthy footsteps as of someone walking softly outside the car.

When presently its cause was detected it proved to be a sound of ill omen. It was the stretching of the ropes under the hot sun, and the silk giving out as the gas continued to expand and send us mounting yet higher.

PLANTS AND THEIR FOOD.

By H. H. W. PEARSON, B.A. (Cantab.).

As we observe the young wheat plants just appearing above the ground, and in a few months' time see the same plants, full-grown and almost ripe for harvest, we cannot but wonder what has been the nature of their food and whence they have obtained it. In the case of animals, at least of the higher animals, ordinary observation is sufficient to give us a good deal of information respecting the nature and sources of the food upon which they live. But no amount of observation will enable us to see anything of the nature of food entering the wheat plants. We know that they have roots in the ground, and can imagine that these take something from the soil which the plants use as food; this, however, teaches us nothing, and we soon realise that we must adopt some other method than that of out-of-door observation before we can hope to obtain the information which we seek.

It is more than 2000 years since philosophers began to speculate about the food of plants and what we may term their "digestive" processes, but it is only during the latter half of this century that really clear and definite notions concerning the food supplies of the vegetable world have been generally accepted by scientific men.

Aristotle could find in plants nothing which might be supposed to digest food materials in the same manner as the stomach of an animal; and he saw no trace of any excrement or useless matter being cast off. He therefore believed that no process corresponding to digestion took place in plants. In order that this might be possible he supposed that the food was not only obtained from the earth, but was so prepared in and by the soil that it could be taken up by the roots and at once applied to the purposes of growth without undergoing any further change. In other words the soil not only supplied the food materials but also digested them and yielded the products up to the roots in such a condition that they could be at once added to

the substance of the plant. Strange as this idea appears to us, it did not finally die out until the XVIIIth century. Passing over the writings of several philosophers who were influenced in a greater or less degree by these ideas of Aristotle, we will notice the views of Van Helmont,* a Dutch physician of the

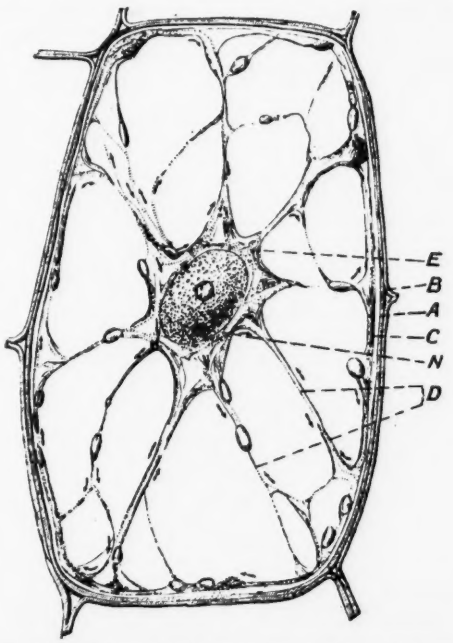


FIG. 1. (After Haustein.)—A living plant cell, very highly magnified. A.—The cellulose wall. B.—The wall of a neighbouring cell, which is not represented. C.—Inner wall of protoplasm (Primordial Utricle). D.—Strands of protoplasm connecting the Primordial Utricle with the central mass of protoplasm (E), in which the nucleus (N) is embedded.—From the figure in Vine's "Physiology of Plants."

XVIth century. He believed water to be the principal constituent of matter, and therefore of the body of the plant. Hence he considered that the food of plants consisted solely of pure water. This idea is nearly as far from the truth as that of Aristotle, but it is historically of great importance because it was supported by an experiment—as far as is known, the first botanical experiment ever performed. He placed in a pot 200 lbs. of dried earth, and in it he planted a willow branch which weighed 5 lbs. He kept the whole covered up and daily watered the earth with rain-water. After 5 years' growth the willow was taken up and again weighed and was found to have gained 164 lbs.; the earth in the pot was dried and weighed and had only lost 2 oz. Knowledge was not yet sufficiently advanced to enable Van Helmont to interpret these striking results correctly, and he came to the erroneous conclusion that the increased weight of the plant was due to the water which had been supplied to the roots. He therefore looked upon this experiment as supporting the theory which he had advanced, viz., that plants required no food but water. But although his conclusions were wrong, yet to him is due the honour of having been the first to adopt the experimental method of enquiry in investigating problems connected with plant life. A hundred years later a very important advance was made by Stephen Hales.† This distinguished English physicist was the first to prove that part at least of the food materials of plants is derived from the atmosphere. The vast importance of this discovery will be realised when we consider the assimilation of the Carbon dioxide (Carbonic acid gas) of the atmosphere by the leaves of green plants. Soon after the death of Hales it was shown that the Carbon of the plant is derived from Carbon dioxide of the air, and that at the same time the water of the soil containing nitrates and other mineral matters in solution is taken in by the roots and utilised as food material. The true interpretation of Van Helmont's experiment was that the increase in weight of the willow branch during the 5 years' growth was in a great measure due to Carbon which it had taken from the air.

By these discoveries a firm foundation for further investigation was laid. Although the progress made since the time of Hales has been far from uniform, it has been great, especially during the last 40 years, as we shall see in our further consideration of the subject. There is nevertheless a wide scope for further enquiry, and much remains yet to be discovered before all the problems connected with plants and their food can be satisfactorily solved.

A leaf-bearing plant may be looked upon as a republic whose units are called "cells." A large proportion of the cells of a living plant are dead, although they have by no means ceased to be of use to the plant; such are the hard fibres of which the wood of trees is largely composed, and which give to the trunk the rigidity which enables it to sustain the heavy weight of the branches and foliage. It is however with the living cells that we are chiefly concerned, in considering plants in relation to their food. We may regard a living cell as a very minute bag or sac bounded by a double wall. The size of the cell varies in different plants and in different parts of the same plant. Some idea of the average size of such cells may be conveyed by the statement that between 6000 and 12,000, spread out in a single layer would cover 1 square inch of surface. The outer wall of the cell (the cell-wall proper) is composed of an elastic‡ substance called "cellulose," which in its chemical properties resembles starch. A cellulose wall permits the passage of liquids through it, and must therefore be minutely perforated, though the perforations are so small as to be quite invisible under the highest powers of the microscope. The inner wall, sometimes called the "Primordial Utricle," closely lines the outer and is composed of a viscid substance called protoplasm, strands of which pass from points in the wall to the interior of the cell, and there unite forming a mass in which is embedded an oval body, the nucleus. The nucleus is also composed of protoplasm, but it possesses many remarkable properties which mark it out as a distinct body. Protoplasm consists of a mixture of substances called proteids, which are composed of Carbon, Hydrogen, Nitrogen, Oxygen, and one or two other elements. Its most remarkable character is that it possesses properties which lead us to speak of it as a living substance. Some of these properties will come under our notice at a later stage. As much of the cell as is not occupied by protoplasm is filled by a

* Born in Brussels, 1577.

† Born in Kent, 1677. Entered Christ's College, Cambridge, 1696. Fellow of the Royal Society.

‡ An "elastic" substance possesses the property of returning to its original shape after being stretched.

liquid known as "cell-sap," which is water holding in solution various materials which have been taken up from without by the roots and leaves. These materials are thus brought in contact with the protoplasm which causes them to undergo changes in composition that prepare them to be added to the substance of the plant. Thus it is in the protoplasm of the living cells of the plant that those "digestive" processes are carried on which Aristotle believed to occur in the soil. We see then that the living cells are microscopic laboratories in which the digestion of the food of the plant is carried on. And now that we know something of the nature of the laboratories to which the food materials have to be conveyed we can the more easily enquire into the nature and sources of the food supply.

As we cannot directly observe substances entering or leaving a plant, we must adopt other methods of investigation before we can learn much about the nature of its food. If we can ascertain of what substances a plant is composed, we shall at least know that by some means or other it has received these substances from outside. For example, when a cigar burns there remains an incombustible grey ash. Chemical analysis of this ash shows that it is composed of various substances, one of which is Magnesium. We know then that Magnesium was present in the cigar. If we were acquainted with the method by which the cigar was manufactured we might go back a step further and conclude that Magnesium was contained in the tobacco leaf from which the cigar was made, and therefore in the food of the tobacco plant. This is an illustration of the actual method employed when we wish to find out what are the substances which a plant acquires from the outside world. The whole of a well-grown plant is thoroughly dried at a high temperature, which is, however, not high enough to burn it. After being carefully weighed, the dried plant is burned in such a manner that not only the ash, but also the gases given off during the combustion, are collected. These are then weighed and analysed. The gases, which weigh considerably more than the ash, are found to be Carbon dioxide (CO_2), water vapour (H_2O), and Nitrogen. We should then conclude, on chemical grounds, that our plant contained Carbon, Hydrogen, and Nitrogen. The ash may contain a great number of elements, many of which are found in only a few plants; of these the following are almost always present—Calcium (a constituent of chalk), Magnesium (found in many Limestones,) Iron, Potassium, Sulphur, Phosphorus, Chlorine, Silicon, and Sodium, all of which are found in the soil. At the same time we should learn that our plant contained Oxygen. (It would take us too far to consider the reasons for this conclusion.)

It will be interesting to place side by side the results of such an analysis of Green Peas and Clover Hay : §

	GREEN PEAS.	CLOVER HAY.
Carbon -	46.5 per cent.	47.4 per cent.
Hydrogen -	6.2 „ „	5.0 „ „
Oxygen -	40.0 „ „	37.8 „ „
Nitrogen -	4.2 „ „	2.1 „ „
Ash* - -	3.1 „ „	7.7 „ „
	100.0	100.0

We cannot discuss here all the information that is contained in these figures. We notice, however, that the proportions of each constituent differ in the two cases, and this is true in all cases, even for similar parts of two plants of the same kind growing side by side in the same soil. And further, we see that in each case the Carbon weighs more than any other constituent. This is always the case in herbs and in the soft parts of woody plants.

This method of analysis shows us what are the elements which a plant takes in from without. But we learn from it nothing concerning the forms in which these elements must be combined before they can be received by the plant. And further, it gives no information as to whether any of the elements in the substance of the plant may be more necessary for the general welfare of the body than any others; in other words, we cannot by mere analysis find out which are the necessary elements of the food as distinguished from those whch can be dispensed with without injury to the life of the plant.

To attack such problems as these we must have recourse to other more direct methods of investigation. The most important of these is the method known as "water-culture." Plants are grown, sometimes for considerable periods, with their roots immersed in water in which various mineral salts are dissolved. "Sand-culture" is merely a modification of "water-culture"; in this the roots are in pure sterilised sand, to which such solutions as are used in water-cultures are added. From a great number of experiments of this kind it is possible to find the composition of a solution in which a plant will grow, for a time at least, as well as if its roots were in the soil under natural conditions. Such a solution, in which most green plants are able to find all the necessary elements of their food, has the following composition:—

Distilled Water - - - -	1,000—1,500 grammes.
Potassium Nitrate (Saltpetre) - - -	1.0 „
Magnesium Sulphate (Epsom Salt) - -	0.5 „
Calcium Sulphate - - - -	0.5 „
Calcium Phosphate or Potassium Phosphate -	0.5 „
A soluble Salt of Iron - - - - -	A trace.

This solution contains all the elements which the roots of a green plant must find in the soil in order that its growth may be healthy. Other mineral elements found in plants are not as a rule essential constituents of the food. The proportions in which these substances are presented to the roots may vary without affecting the growth of the plant, for the roots have the power of regulating the quantities of each substance absorbed, so that none enters in excess. An important point to be noticed in the composition of this nutrient solution is that Carbon is not present in it in any form whatever. A green plant is able to obtain all its Carbon from the atmosphere, though, as we shall see later, it is quite possible that in Nature some of it is absorbed by the roots.

§ Vine's "Physiology of Plants."

* All the mineral constituents are here included.

EXPLOSIONS IN COAL MINES.

By JOHN MILLS.

A MOST important example of an industrial result depending upon pure induction from abstract science is afforded by the Miner's Safety Lamp. The processes which, in the course of ages, have resulted in the production of coal—the preserved matter of primeval forests—the remains of a vegetable world, have also yielded an abundance of inflammable gas. This gas, known to miners as "fire damp" and to chemists as carburetted hydrogen, accumulates in the cavities and fissures of the coal itself, and of the adjacent strata; it is identical in composition with marsh gas, which causes the phenomenon known as "will-o'-the-wisp."

Fire damp, the scourge of the miner, more dreadful

in its effects than those of the lightning and the earthquake, long defied investigation even as a scientific phenomenon. An element of destruction, apparently uncontrollable by human power, had to be grappled with and subjugated so completely as to be put under the management of the most uneducated miner. The gas in many mines is constantly issuing from the coal as it is worked, and sometimes emerges under great pressure when the cavity containing it is punctured by a pick or other means, the term "blower" being applied to such an escape of gas. When mingled with air, this gas forms a mixture which explodes violently in contact with a naked light.

By a pure inductive method Sir Humphry Davy traced its history, step by step, until he fully made out all its characters. He discovered that fire damp in reality requires a very high heat for ignition, the temperature of red-hot iron or charcoal being insufficient to inflame it. The gas was found not to explode in narrow tubes, as these cool it below the point of ignition, and a network of iron or copper wire is practically equivalent to a series of sectional tubes. A lamp surrounded by wire gauze was therefore used, and this allowed a light to be carried into the mine with safety. The destructive gnome of the mine was thus imprisoned within a cage of mere wire gauze, and, vainly struggling to escape, heated to redness the bars of its prison, thus affording warning of the presence of the gas in dangerous quantity. Science, to its glory, by this simple means greatly minimised those scenes of death and heart-sickening misery which haunted the miner in his most peaceful hours, and has rendered comparatively safe an occupation formerly one of dread and real danger.

"Black damp," the deleterious constituent of which is carbonic acid gas, is also evolved in coal mines, and though incombustible and inexplosive, it is fatal to life if allowed to accumulate to any considerable degree. Elaborate systems of ventilation are therefore in use to carry off these gases so as to prevent undue accumulation. Pure air is forced, pumped, or sucked down one shaft, and vitiated air let out at another, both shafts communicating with the surface, and the current thus set up sweeps out the mine, so to speak, but the "fire damp," being lighter than air, is liable to accumulate in inequalities of the roof and has sometimes to be dislodged by special appliances.

The main cause of death in explosions, however, is not the explosion itself, but the "after damp" generated by it. Dr. Haldane, who visited Tylorstown Colliery on the day after the terrible explosion there on January 27, 1896, resulting in the deaths of 57 out of 90 men in the pit, has shown that an examination of the bodies revealed the astonishing and unexpected fact that 52 out of the 57 deaths, that is, no less than 91 per cent., had been caused by "after damp," the remaining five having been killed instantaneously by violence. Of the men killed by "after damp," a post-mortem examination showed that in nearly every case the signs of carbon monoxide poisoning were present.

The safety lamp, in its present improved form, if carefully used, affords adequate protection, but it has been found when the lamps are left in the miner's possession and custody after he quits the mine, they are sometimes damaged by careless handling, and taken back into the mine in a defective and dangerous condition, with appalling possibilities. By the Coal Mines Act of 1896 legislation provided for the safe custody of all lamps used in mines, the removal of any lamp from the mine being forbidden.

But there are other sources of explosions in mines. The primitive wedge, used from time immemorial for detaching coal from the mass forming the seam, has been superseded by the disruptive energy of explosives—the so-called "shot" in blasting operations. A shot improperly fired is called "a blown out shot," and the initial cause of the explosion is the jet of flame projected by the blown out shot. When the "stemming," or "tamping," used for confining the explosive within the boring prepared for it is not sufficiently rammed in to secure the complete internal combustion of the explosive, "a blown out shot" may be produced, and the effect is to cause a jet of flame to issue with great force from the orifice of the boring at the moment of the shot, so that if "fire damp" be present in quantity an explosion occurs and may extend throughout the mine.

As some explosives are unduly dangerous, the Secretary of State, in accordance with the provisions of the Act of 1886, has had drawn up a "Permitted List," that is, explosives which owners of mines are required to choose from as safest and best. At Woolwich Arsenal there is a station provided with apparatus designed to test the effect of firing explosives in presence of inflammable mixtures of atmospheric air with either coal-gas or coal-dust. The charge of explosive is fired from a steel cannon with a uniform stemming of dry clay, these conditions representing very closely those of "a blown out shot." No explosive was considered to have satisfied the test if it caused more than two failures in forty shots—a failure being either an ignition of the gaseous mixture or an incomplete explosion leaving a residue of explosive unconsumed.

Another medium of disaster is coal dust, harmless enough till the work of destruction has once been started; existing everywhere in the labyrinthine passages, as dust suspended in the air, it serves as a ready distributor of flame and, therefore, explosion in all directions from the local point of origin. It may be seen in miniature when dry and dusty coal is thrown on a fire from a coal scuttle, the finer coal dust is immediately inflamed by contact with the glowing coals in the grate, and passes up the chimney in the form of a feeble explosion.

Faraday, on scientific and experimental grounds, suggested that coal dust contributed largely to the devastating effect of an explosion. A zone of safety is generally obtainable by saturating the dust in the immediate neighbourhood of a contemplated shot. It is estimated that the total number of shots fired in the United Kingdom amounts to at least 20,000,000 annually.

Between 1851 and 1889, inclusive, there were 2,060 colliery explosions, and the number of lives lost was 8,859; during that period some 900,000,000 shots must have been fired, giving a percentage of explosions to shots of 0.000229, and of lives lost to shots of 0.000985. In the decade ending 1882, the ratio of mortality by explosions of fire damp was .65 per 1,000 persons, in the next decade .32. In 1893 it was .29, and in 1894 .56. Lower still in 1895—namely, .10, and up at .31 in 1896. In 1897, the first year in which the new Act was in force, the ratio fell to .03, and in 1898 it had risen a little—namely, to .05. The accompanying table shows the number of persons employed underground in coal mines and the output for the years given:—

Year.	Number of Persons Employed.	Output in Tons.
1896 ...	557,026 ...	208,503,868
1897 ...	558,305 ...	215,145,025
1898 ...	567,124 ...	215,161,954

XUM

It is gratifying to learn that the efforts put forth by the Legislature in recent years for the effectual prevention of explosions in coal mines are being attended by results which show that mortality is not near so rampant as it was formerly. In the last two years, that is, in the two years which, at the end of 1888, had elapsed since the Act came into force there had been no great and devastating explosion. Still, even now, our knowledge of the causes, circumstances, and effects of explosions in mines, whether of fire damp, of coal dust, or of both, is still very far from complete—indeed, is in many respects of little more than a rudimentary character. But let us not under-estimate the labours of those who have captained us thus far in our conflict with the miner's deadly foe.

THE NATIVES OF AUSTRALIA AND THEIR ORIGIN.

By R. LYDEKKER.

IF the visitor to the Natural History Museum at South Kensington direct his attention to a case in the upper Mammalian Gallery bearing the superscription "Comparison of Man and Apes: Craniometry," he will scarcely fail to be struck by the remarkable difference presented between the palates of three skulls placed side by side, and respectively labelled Mongolian, Australian, and Chimpanzee. In the first the teeth, which are of comparatively small size, form a regular unbroken horseshoe-like curve, as they likewise do in a European; while the bony palate of the skull is so short that its transverse diameter considerably exceeds the longitudinal. On the other hand, in the Australian skull the individual teeth themselves are larger, and instead of the whole series forming a regular horseshoe, the line of grinders on each side, together with the eye-tooth, or canine, forms a distinct angle with the incisor line in front. Moreover, the palate is longer and narrower than in the Mongolian skull; the length of its longitudinal diameter exceeding the transverse. Turning to the Chimpanzee skull, the observer will notice that the features indicated in that of the Australian are intensified; the palate itself being much longer than broad, while the teeth are proportionately very large, and those on each side are arranged in a straight line, curving slightly inwards, and forming a marked angle with the incisors in front, from which they are separated by a distinct gap.

Looking at the three palates, the impartial observer can scarcely fail to see that although the Australian is nearer to the Mongolian than it is to the Chimpanzee, yet it forms a very marked step in the direction of the latter, and that if we had but one more link, the gap between the Mongolian and Simian palates would be practically bridged. Indeed although, judging from the skull alone, the European should have no hesitation in claiming the Australian as a fellow man, yet to say that he is a "brother" would be stretching that somewhat elastic term very hard indeed—an extremely distant cousin would more adequately express the relationship!

Had we only Australians on the one hand and Europeans and Mongolians on the other to deal with, it appears highly probable that we should be perfectly justified in regarding the former as a distinct species of mankind. For not only is there the above mentioned striking difference in the structure of the palate, but (not to mention other points of distinction) the spinal column of the Australian lacks the full development of the exquisite curves of that of the European, and thus approximates to the Chimpanzee and Gorilla. As a matter of fact, however, the frizzly-haired Melanesians of Oceania, as well as the true Negroes of Africa, stand in some degree intermediate between the Australian and the European in respect to the structure of the skeleton, and thus forbid us regarding the former as a species apart.

One of the greatest puzzles in the science of anthropology is indeed to understand the relationship of the Australians to other races of mankind. In their skeletal structure they undoubtedly come nearest to the Melanesians and the African Negroes, although presenting a still more primitive type. Their black complexion, thick and pouting lips, projecting jaws, large teeth, and long skulls are indeed essentially Negro characters. Their eyes, too, are deeply set in the skull, and their legs show little or no calf. In the prominent ridges over the eyes, they frequently exhibit (see Plate) a resemblance to the Melanesian rather than to the African Negro type, in which these brow-ridges are undeveloped. Australians likewise resemble Negroes in that the colour of the skin of the infants is light yellow or brown instead of black; the adult sable tint not being acquired till between eighteen months and two years of age.

But (and this is a very large "but" indeed) here the resemblance ceases; for all Australians are broadly distinguished from Negroes and Melanesians—even their near neighbours the Tasmanians—by the character of their hair, which, in place of being "woolly," or frizzly as it may be better termed, is at most bushy, curly, or wavy; being generally coarse in texture and black in colour. The beard and moustache are likewise well developed; and in fact, as the illustrations show, Australians cannot be distinguished by their hair from the wild tribes of India, who are generally regarded as having no near relationship with Negroes, and who display no markedly low type in the form of the palate.

Before attempting to consider the meaning of this marked difference between Australians on the one side and Negroes and Melanesians on the other, it may be well to devote a few lines to the essential distinction between frizzly and other types of hair. If sections be taken from the hair of a horse's tail or mane, and then be examined under a microscope or lens, it will be found that they are perfectly circular; and the entire hair being thus cylindrical, it naturally hangs straight down. The lank black hair of a Japanese, a Chinese, or an American Indian is of the same cylindrical type. On the other hand, the hair of an average European when seen in section presents an oval ellipse, and thus causes the waviness so frequently noticeable. When, however, the hair of a Negro or Melanesian is sectionised, it is found to present a flat ellipse; and it is owing to this peculiar structure that the hair of these peoples assumes its characteristic frizziness. Now it is very noticeable that in crossbred races, such as the Brazilian Capesos (Negro and Native half-breeds, who are mop-headed like the Papuans), this frizziness of the hair tends to persist; and a hybrid described as half Negro, a quarter Cheroki, and a quarter English, is stated to have retained the Negro "wool." Hence it has been suggested that frizzly hair represents the primitive human type of capillary adornment.

But if we examine the hair of a Chimpanzee,

Gorilla, Orang-utan, or indeed any other Old World Ape or Monkey, it will be found to be of the straight type, and to show not the slightest tendency to frizziness. Clearly then, from the evolutionary point of view, the straight-haired type ought to be the original one; and we find the late Sir W. H. Flower saying that the frizzly type "of hair is probably a specialisation, for it seems very unlikely that it was the attribute of the common ancestors of the human race."

If this hypothesis be true, it would point to the conclusion that the Australians are a more primitive type than the Melanesians and Negroes; a view which receives strong support from the primitive characters presented by their skeletons. But it must be observed that Sir William Flower, in spite of the opinion expressed above, suggested that the Australians are a mixed race, derived from a crossing between frizzly-haired Melanesians and some low type of the Caucasian stock, such as the wild tribes of Southern India. It may be urged, however, from what has already been said in regard to its persistence among half-breeds, that the frizzly type of hair would be very unlikely to have so completely disappeared among the Australians; added to which is the circumstance that had such extensive crossing with the Caucasian stock taken place the Australians could scarcely have preserved such an extremely low type of skeletal structure—a type which, at least as regards the palate and the spinal column, appears lower than that of either Melanesians or Negroes.

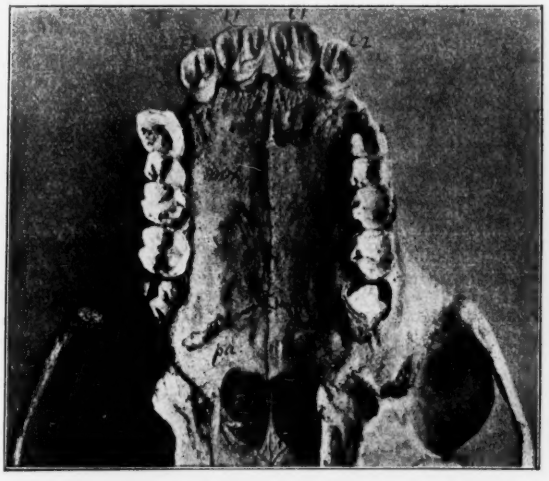


Fig. 1.—Palate of Skull of Chimpanzee.

That the Australian aborigines reached their present home from south-eastern Asia may be regarded as almost certain; and some have considered that the migration took place at a time when there was still a more or less complete land connection between Malaysia and Australia. Moreover certain South Australian tribes are considered to be closely related to the ancient inhabitants of Europe, as typified by the famous Neanderthal skull. Hence there is nothing improbable in the supposition that both of the Australians and the primitive Caucasian tribes of India are the descendants of a common stock, the Australians having retained the primitive character of their Neanderthal ancestors, while the Indian tribes have attained a higher grade of evolution. On this view the frizzly-haired Melanesians and African Negroes, as well as in all probability the round-headed Negritos of Luzon, in the Philippines, would be descendants from the primitive stock of which the Australians are less modified representatives. And in this connection it is important to mention that Dr. O. Finsch, who has travelled much in Australia, is of opinion that the Australian aborigines form a single and peculiar race, which differs more from either typical Melanesians or Papuans than do both the latter from African Negroes.

The general physical similarity of the natives from all parts of Australia is indeed a very striking peculiarity of the race, and serves to show that, whatever be their origin and their relationship, they have been, previous to the European colonization of their island continent, isolated for an immense period of time from the rest of the human race.

Their unity of type and isolation from other races is strongly emphasised by their language, which while uniform throughout the country, is at the same time quite distinct from that of any other people. It has indeed been attempted to connect the Australian tongue with that of the Dravidian races of Southern India, but this, according to recognised experts, is stated to have resulted in total failure.

There is, however, a very curious connection between the Australian aborigines and certain of the wild tribes of Southern India, namely that both possess the boomerang; a weapon unknown to any other members of the human race.* Of course there is the possibility that this very remarkable implement has been independently invented by the two people who use it, but there is a considerable degree of improbability in this idea. If, on the other hand, it be an inheritance of the Australians from Asiatic ancestors, it may be fairly argued that it is unlikely to have been evolved at the extremely remote epoch when the ancestral Australians started from their Asiatic home. And if this view be accepted, then we are compelled to revert to the idea of a later immigration from Asia, which brings us again to the question of the origin of the wavy hair of the Australians.

Apparently there is no possibility of giving a definite answer as to the origin of the boomerang; but there is one very curious point which may indicate the great antiquity of its introduction. As most of my readers are aware, the Australian aborigines possess a semi-domesticated dog—the Dingo; and there are strong reasons for regarding this animal as not pertaining to the indigenous fauna of the country. Its remains are, however, met with in association with those of a number of extinct animals, so that the date of its introduction was evidently very early. But if, as some suppose, man reached Australia at a time when it was much more closely connected with Malaysia than is at present the case, his advent might well have been contemporaneous with that of the Dingo. And here comes in the point referred to, namely, that (as I learn from an expert) the Dingo is very closely related to the Paria dogs of India. Now since these latter are domesticated breeds, the evidence, if it may be relied on, points to a very early immigration into Australia of aboriginal tribes accompanied by dogs from Asia. And if such early aborigines had domesticated a dog, they might surely be deemed capable of having invented the boomerang.

* The boomerang of India has not the return flight of the Australian weapon.

Like all tribes who have been brought into connection with Europeans, the Australian aborigines, especially in the districts longest colonised, have altered—and frequently for the worse—from their primitive condition; while they have also sadly diminished in number. Writing, under the pseudonym of "An Old Bushman," so long ago as 1860, an observant settler in the vicinity of Melbourne made the following remarks:—"Of the many thousands who inhabited the colony before the arrival of the white man, not 2000 survive, and most of these are on the banks of the Murray. Although debased far below their own savage level since their intercourse with the white man, the few that are left still retain much of that free independent spirit and wild roving disposition which characterize all savages who, have to get their living by the chase. For although they get their rations all the year round at the head station, they never care to live long in one place; but, following up the habits of their early life, make periodical excursions into the bush at different seasons, when the different game is in Thus swans' eggs, kangaroo, ducks, eels, and crayfish, all furnish them with food and occupation at different seasons."

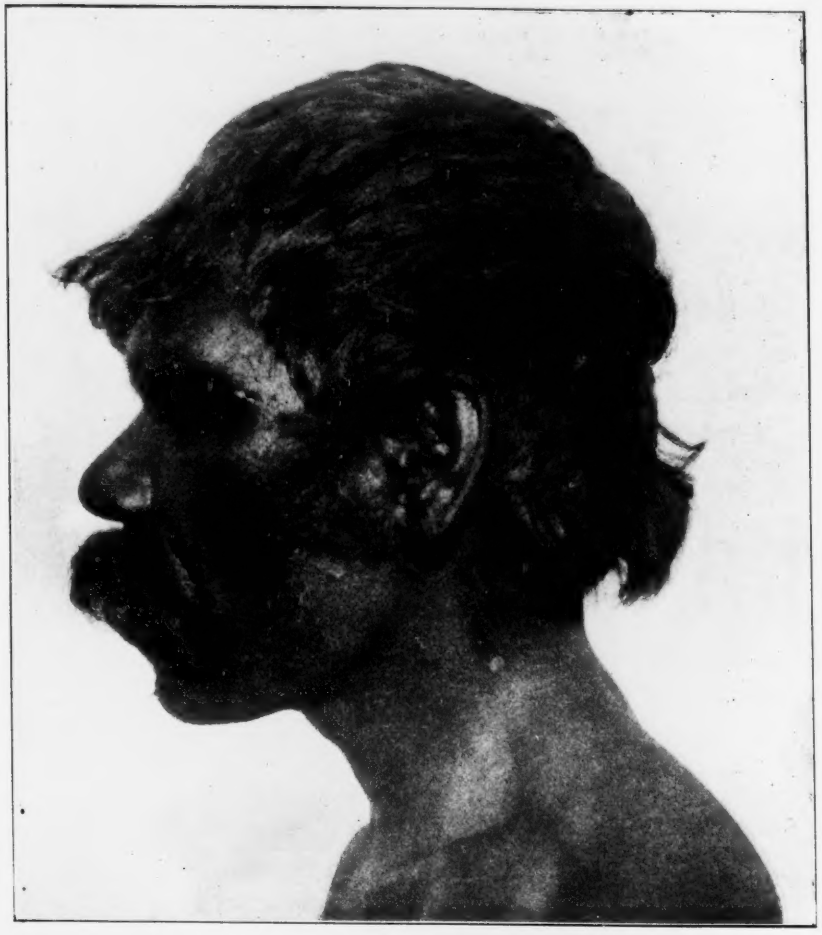
FIG. 2.—Group of West Australian Aborigines.

The procuring of a sufficient supply of food is indeed the great problem of the life of the aboriginal Australian; especially as his weapons, with the exception of the boomerang, are of an extremely poor description. Consequently these people, if we may judge from the accounts of those who have had the best opportunities of observing them, are some of the best, if not actually the best hunters and trackers in the world; indeed, Dr. Semon unhesitatingly assigns to them the highest position in this respect. Nothing that can be in any way regarded as edible seems to come amiss to an Australian, even such unsatisfactory morsels as grasshoppers, beetles, and fleas being consumed with relish. Probably the difficulty of obtaining a sufficient food supply from other sources was originally the reason that cannibalism came into vogue, but when once established it assumed a prominent place, Dr. Lumholtz telling us that human flesh is the greatest dietary luxury that these people in their primitive condition enjoy. In the proper sense of the term the Australian appears to have no religion at all; at any rate it has been authoritatively stated that he has never been observed either to pray, worship, or offer sacrifice, and that in his natural condition he has no sort of conception of a future state of existence. His extremely low grade of development is likewise strikingly exemplified by the treatment accorded to the female sex—a treatment perhaps only paralleled among the Fuegians. Such of my readers as wish to learn how brutal this treatment is, may refer to the works of Dr. Semon and Mr. Brough Smyth; but no good object would be gained by quoting the pitiful details in this place. Neither need detailed reference be made to the complicated system of class marriages which obtains among certain of the tribes. Although under a careful system of education in European schools the native children are capable of acquiring a certain amount of knowledge, displaying a decided capacity for drawing, there can be no doubt that the mental capacity of the Australian in his primitive condition stands at an extremely low level. No better exemplification of this can be cited than his arithmetical capacity—or rather incapacity. So low indeed does he stand in this respect, that none of the tribes have a word to express a number higher than three, while some content themselves with those for one and two. Mr. E. M. Carr is of opinion that no uninstructed Australian native can by any possibility count even as high as seven correctly. "If you lay seven pins on a table," he writes, "for a Black to

NATIVES OF WESTERN AUSTRALIA.

From Photographs by the Curator of the Perth Museum.

Full-face Portrait of a Woman, exhibiting the long wavy hair, broad nose, and thick lips, characteristic of the race.



Profile View of a Man. Shows the deep notch at the junction of the nose with the forehead, which forms such a marked feature in Australians.

reckon, and then abstract two, he would not miss them. If one were removed, he would miss it, because his manner of counting by ones and twos amounts to the same as if he reckoned by odds and evens." It is difficult to imagine anything much lower than this.

Perhaps their one redeeming quality is their honesty and truthfulness; the "Old Bushman" stating that though they will ask for any article that may take their fancy, as if they had a right to it, yet that he never knew them to steal. All who have had much intercourse with them agree that they are naturally a merry and humorous people, with a great capacity for mimicry, taking off with facility any peculiar personal mannerism of those with whom they may be brought in contact, or imitating the movements of the kangaroo and the emu.

To work of all kinds they have a rooted objection, and the writer last mentioned gives it as his opinion that it would be impossible to make a slave of an Australian Black. Nevertheless, if I may judge from certain photographs lent me by Mr. B. Woodward, of the Perth Museum (to whom I am indebted for those illustrating this article), the aborigines remaining in the settled districts do now perform a certain amount of labour. They have also taken (as shown in the annexed illustration) to European clothing—of sorts. But, to quote once more from the "Old Bushman," the Australian ladies, who are by no means remarkable for personal beauty, at least from a European standpoint, "seem to care nothing for finery or ornaments, a dirty blanket, or opossum-rug wrapped loosely round them, and a short black pipe stuck in their hair completes their toilet." Not improbably my lady readers will consider this a more convincing proof of the low grade of the Australian aborigines than any other instance that could be mentioned!

Since writing the above, I have had an opportunity of carefully reading Dr. Semon's book "In the Australian Bush," and am pleased to find that he agrees with the views here expressed as to the racial distinctness of the Australian aborigines from their neighbours. But he goes a step further than I have ventured to advance, and suggests that the Australians are really near relations of the Veddas of Ceylon, and are therefore in reality a low branch of the primitive Caucasian stock, and have nothing to do with Negroes, to whom they are commonly affiliated.

ASTRONOMY WITHOUT A TELESCOPE.

I.—INTRODUCTORY.

By E. WALTER MAUNDER, F.R.A.S.

SOME years ago, when the Sioux Indians were beginning to get restless and to threaten trouble, it was thought expedient by the authorities at Washington to invite some of the discontented chiefs to an interview with their "Great White Father," the President, and, incidentally, to give them a demonstration of the vast resources which they would have to encounter if ever they took up arms against the Federal Government. So they came, and were shown some of the mighty machines which modern engineering has produced and in particular some hundred-ton guns. The monster weapons were duly manœuvred for the red men's benefit. They were loaded and fired, and the Indians were conducted to the ruin which had been the target that they might mark the terrible destruction which the missile had wrought. The Indians looked, but instead of being overwhelmed with astonishment and fear, as their guides had expected, betrayed only a slightly bored indifference. The United States official in charge of the demonstration repeated and emphasized his explanations when one of the chiefs, with just the faintest ghost of a satirical smile, which was the utmost manifestation of feeling his stoical sense of dignity allowed him, said, pointing to the unwieldy weapon, "You won't come after Indian with that."

It was true! The officials felt its force at once, and the Indians were treated to no more exhibitions of heavy artillery practice. It had been forgotten that the most powerful weapon is not necessarily the most effective for every purpose, and that for some classes of work the great size of an instrument may be a fatal disqualification.

A very similar mistake is sometimes made in regard to astronomy, and has no doubt interfered with the popularity of the science as a pursuit. It is too often assumed that nothing of real interest or utility can be achieved without the possession of telescopes of enormous power and of corresponding cost. The great observatories maintained in various European countries by the State, or founded in America by millionaires, like Lick or Yerkes, have been thought to command a monopoly of the astronomical advances of the future, since they only possess the telescopes of greatest light-gathering power and most perfect definition.

This view is far from correct. In the first place such an assumption entirely overlooks a consideration expressed as follows by Mr. W. H. Maw, F.R.A.S., in his recent most admirable Presidential Address to the British Astronomical Association, an address to which I would refer all who are likely to take up practical work in astronomy. Mr. Maw points out that

> "By the time a refractor of this kind has been erected and equipped, the outlay upon it will have become so large that it would be utter folly to use the instrument for work other than that for which its great power renders it specially fitted. The result of this is that our modern giant telescopes are, with few exceptions, employed, not in doing work which was formerly done by smaller instruments, but in doing work which formerly could not be done at all. Such, for instance, is the bulk of stellar spectroscopic work, including determinations of velocity in the line of sight, the measurement of close double stars, the spectroscopic examination of nebulæ, the discovery of new planetary satellites, and similar matters. We see, therefore, that the establishment of these powerful telescopes has been accompanied by the development of new fields of research, and that the work which was formerly done—and can still be well done—by instruments of moderate size has not been reduced." *

Nor is this all. Not only are the new giant telescopes necessarily devoted almost entirely to work which smaller instruments cannot touch, thus leaving to the latter the observations within their compass, but there are departments of work for which a great refractor is as wholly unsuited as a hundred-ton gun would be for fighting a Red Indian or shooting snipe. Great light-gathering power is not always the most important quality; for some researches broad grasp of field is far more essential, and here the giant telescopes are practically useless.

Prof. E. E. Barnard, in one of his lectures on Astronomical Photography, illustrated this point by showing a photograph of the great nebula in Andromeda, with all the marvellous detail of ring within ring which the photographs of Dr. Roberts and his followers in this field have made familiar to us. Then over this

* *Journal of the British Astronomical Association*, Vol. X., No. 1, p. 8.

XUM

he would place a mask, cutting down the field of view to the area which was the largest which the great 36-inch refractor of the Lick Observatory could command. It was seen at once that, however powerful the light-grasp of that telescope, it was quite beyond it to give any idea of the structure of so large a body as the Andromeda nebula, when considered as a whole.

But there are other objects in the heavens of far vaster area than the Andromeda nebula, and to deal with these in their full extent requires a wider field than any telescope can cover; they must be observed directly with the unassisted eye.

There are, then, definite branches of astronomy in which the telescope is not only unnecesary but, more than that, it is a hindrance. Apart, however, from this, it is well to remember that the science was pursued with great success for some thousands of years before ever the telescope was even conceived. The length of the year, the obliquity of the ecliptic, the fact and amount of precession, the chief lunar inequalities, the inclinations of the planetary orbits, and their relative dimensions were all determined by direct eye observation, and with a really remarkable approximation to the truth. Indeed, in our own day the same feat has been repeated, for, as readers of KNOWLEDGE will remember,* there is still living in Orissa the Hindu astronomer, Chandrasekhara, who, with home-made instruments and without optical assistance, has redetermined the elements of the chief members of the solar system with a most astonishing accuracy. Work of this kind may not indeed "increase the sum of human knowledge," for it is to repeat with very small and imperfect means what is being done with the most perfect appliances in the great public observatories of the world. But it is far from being waste time and effort on that account. As a training in keenness of perception and in habits of order and accuracy in observation it will be of the utmost service. It is not every man who climbs the ropes of the gymnasium who expects or wishes to become a sailor, and so to turn the skill he acquires to direct service in exactly the same line; but the strengthening of his muscles and the increase in agility are solid gains to him none the less.

Mr. Maw's words† on this subject also are well worth quoting, and I make no apology for introducing them:—

> "What was done in the olden times can be done in the present day, and I wish to prominently direct the attention of beginners to the fact that by the employment of quite simple apparatus they may make observations which will bring home to them in a way which mere reading can never do, a knowledge of many astronomical phenomena which they will find to be, not only of immediate interest, but of great value to them in their further studies
>
> "What I wish to urge, therefore, is, that those commencing the study of astronomy should not be content with reading only, but should work in the open air, faithfully and systematically recording their observations, however elementary these may be. I lay great stress on this latter point, because unrecorded observations have, as a rule, little educational value. The mere fact of describing in writing any observation, however simple, which has been made is of immense assistance in securing completeness and accuracy. Of course, the country offers greater facilities than towns do for this out-of-door work, but there are few towns where access cannot be had to some convenient site giving a fairly clear horizon and sufficiently free from traffic to allow of star maps being referred to without serious inconvenience. Naturally the beginner's first endeavour will be to identify the brightest stars and trace out approximately the confines of the various constellations. Continuing this study he will gradually acquire a knowledge of the paths followed by the stars in their courses from rising to setting, and obtain a clear idea of the position of the apparent axis of this motion. As time goes on, he will further notice that the constellations he has identified set earlier and earlier each evening, and that other constellations previously unseen will come into view on the eastern horizon. Further, he will notice that the path followed by the moon in her course through the sky not only differs at different parts of a lunation, but varies for any given part of a lunation at different seasons of the year. As his knowledge of the sky progresses, he will be able to identify any bright planets which may be visible, and to observe their changes of position with regard to the adjacent stars, changes which he will do well to note in his sketch-book for future reference and consideration. Now, the beginner who has learned these elementary facts by actual observation of the sky, and has subsequently by the aid of his text-books mastered the reasons for what he has observed, will have made a very fair start in the study of astronomy, and he will, I venture to think, have acquired a far keener interest in the motions of the heavenly bodies than he would have possessed if he had confined his attention solely to books, or if his open-air observations had not been of a systematic character. He will also find that by the aid of some very simple home-made instruments, such as a cross-staff, a rude form of transit instrument, and other similar appliances, he will be able to make observations which serve to still more impress upon his mind the facts he has been learning. Of course, such observations must be crude and wanting in accuracy, but they will, nevertheless, be found to serve a very useful educational purpose."

It is therefore possible to become a real astronomical observer without a telescope and without any outlay except that necessary to procure a good star atlas. And although it may appear a useless labour thus to traverse for oneself the steps by which the early astronomers attained a knowledge of the universe, yet the value of the training involved will be immense, and the delight to be derived from personally watching in progress the majestic movement of the heavens, the sublimest machine in creation, will soon be felt to be enthralling.

But however great the interest that may be taken in work of the kind just described, the observer will be sure, ere long, to desire to do something which shall be of value for its own sake, as well as for its secondary effect as training. And, as has been already intimated, there are certain fields, by no means too fully cultivated, which are full of interest, and for which no giant telescopes are required; indeed, in these domains, the unaided eye is the ideal instrument.

First of all, there is the observation of Meteors. The past November has afforded a great deal of popular interest, of a sort, in the subject of meteors. Articles and letters in all the newspapers of the land excited general expectation to the utmost. Everyone was anxious to see a display of natural fireworks, exhibited without charge, and which would utterly outdo any efforts of human pyrotechny. It is perhaps no loss to science that the expectation was doomed to disappointment. But though everyone was eager to be a spectator at a magnificent display, there are very few indeed who have cared to become serious observers of meteors. Yet the work is of great interest and value, if systematically carried out; and the work of a single observer, Mr. W. F. Denning, has supplied us to-day with the most perplexing problem that still remains without solution of all astronomy; the problem of "stationary," or "long enduring radiants."

Next, comes the study of the Milky Way. Here again no telescope is required. A clear sky, keen sight, and great patience are the requisites. And this field is also one which scarcely any observer has taken up. When we have mentioned Heis, Boeddicker, Easton, and Wesley, we have almost exhausted the roll of explorers of the Galaxy. Yet night after night its mysterious convolutions are drawn out athwart the sky,

* See KNOWLEDGE for November, 1899, p. 257.

† *Journal of the British Astronomical Association*, Vol. X., No. 1, p. 12.

the ring which encloses our universe; the true Mitgard snake that encircles the entire world. Only to the most constant and patient scrutiny will it give up its secrets; yet how large a proportion of the mystery of our Cosmos is involved in an understanding of its structure who can tell?

Thirdly, there is the Zodiacal Light. We in these high northern latitudes are not well placed for watching it; but it can be seen from time to time, and a thorough use of the opportunities that do come will go far to compensate for our less favourable position. And it is worth mentioning, in this connexion, that the Gegenschein, the faint counterglow to the sun, more difficult and elusive than the Zodiacal Light proper, was independently discovered by an Englishman, and not a dweller in Southern England at that, by Mr. Backhouse of Sunderland.

In the Zodiacal Light, and the Gegenschein, we have again objects of the greatest interest and mystery, which are quite unfitted for telescopic examination, are truly naked-eye objects, and which to this day have never been sufficiently observed.

Fourthly, there are Auroræ. At the present period of the sunspot cycle there is no reason to expect any immediate recurrence of these beautiful phenomena. But careful training in the knowledge of the constellations and in the three branches of work just mentioned will be the best possible preparation for properly observing Auroræ when they set in again. And this is most important. After a great display it is very easy to collect a number of most vivid and picturesque descriptions, but really useful and scientific accounts are apt to be sadly wanting.

All these four branches of astronomy are essentially for the naked eye; in a fifth, that of variable stars, a great deal may be done without a telescope in the strict sense of the word, that is to say, a good opera-glass will suffice for a considerable number of objects. An opera-glass also greatly adds to the number of objects which are brought within the observer's range of vision. In the series of papers to which the present is intended to serve as introduction, it is my intention therefore not to limit myself entirely to work which can be done without any optical aid at all, but to include in "Astronomy without a Telescope" observations for which a good field-glass will suffice.

My programme, therefore, may be divided into four parts. First, lessons in the configuration of the constellations, so that the principal stars may be easily recognised. Second, simple observations with the naked eye for training in the habits of astronomical work. Third, observations with the naked eye of Meteors, the Galaxy, the Zodiacal Light and Auroræ. Lastly, observations with the help of an opera-glass; mostly of Variable Stars.

THE CONSTITUENTS OF THE SUN.

By A. FOWLER, F.R.A.S.

OF all the heavenly bodies open to our enquiries, the Sun is the one which can be best submitted to the processes of spectrum analysis; in the first place because its light is so brilliant that instruments of great power can be utilised, and in the second place because it is near enough to admit of its component parts being separately observed. Through the use of spectroscopes of high dispersion, and the increased attention given to spectroscopic work during recent total eclipses, the data at our disposal for deductions as to the chemical constituents of the sun have of late been enormously extended, and it may serve a useful purpose to briefly summarise the present state of our knowledge on this subject.

Information relating to the solar elements is arrived at by three different routes. First of all, there is the Fraunhofer spectrum of dark lines, by which we may investigate the constituents of that part of the sun's atmosphere which produces discontinuous absorption; then there is the bright line spectrum of the chromosphere and prominences; and, finally, that of the corona. (Fig. 1.)

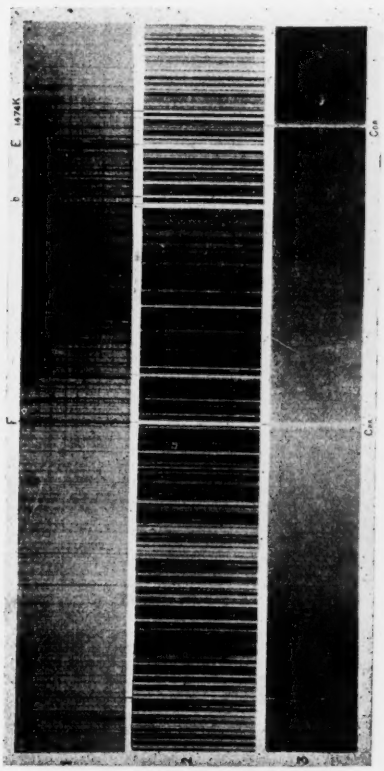


Fig. 1.—The three sources of information as to the composition of the sun. (1) Fraunhofer spectrum of dark lines. (2) Bright line spectrum of the chromosphere. (3) Bright line spectrum of the inner corona. (The F line in this spectrum belongs to the chromosphere.)

As to the Fraunhofer spectrum, the most recent research bearing upon the elements entering into the sun's composition is that of Professor Rowland, who has catalogued close upon twenty thousand lines between wave-lengths 2975.5 and 7331.2 by the use of his splendid concave gratings. Some hundreds of these dark lines owe their origin to the absorbing powers of their own atmosphere, through which the sun is of necessity viewed; but, as a rule, these are readily distinguished from true solar lines by their increased thickness when the sun is near the horizon, by their freedom from the displacement which is common to all true solar lines when the advancing or receding limb of the sun is observed, or by their increased thickness when the air contains a great deal of water vapour. (Fig. 2.)

The chemical significance of the true solar lines is most satisfactorily determined by photographing side by side the spectrum of the sun and that of the substance under investigation. Such a comparison at once shows whether there are any coincidences of the solar and terrestrial lines, and if there is an exact agreement, we are entitled to conclude, in accordance with Kirchoff's law, that the substance in question is present

among the vapours which surround the bright shell from which most of the sun's light proceeds. This method was adopted by Sir Norman Lockyer about twenty-five

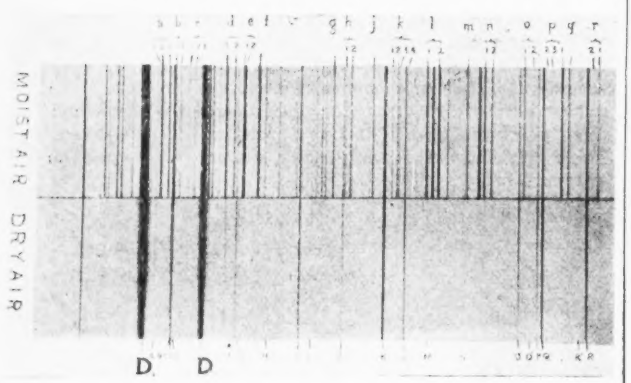


FIG. 2.—A portion of the Solar Spectrum showing intensification of lines due to aqueous vapour in our atmosphere when the air is moist. (Crewe.)*

years ago, and more recently Prof. Rowland has, in this way, compared the spectrum of the sun with that of every known element except gallium. The majority of the stronger lines have now been identified with respect

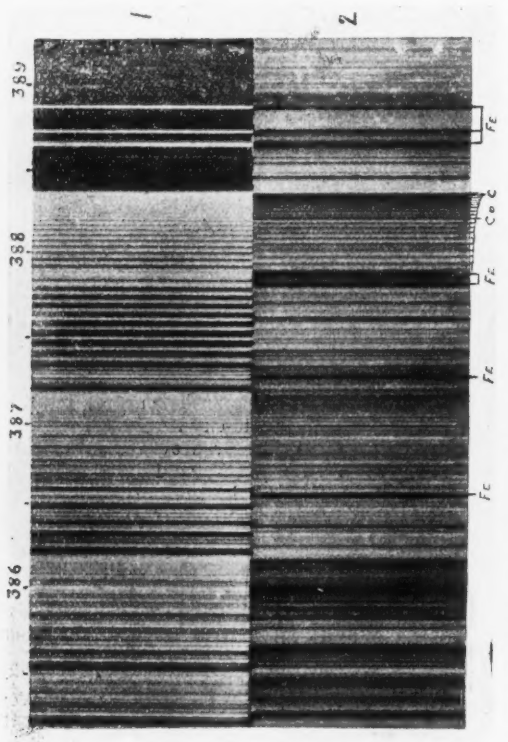


FIG. 3.—A "Solar comparison," showing how the presence of carbon in the Sun is demonstrated. (Lockyer.) (1) Carbon flutings in electric arc, with iron impurity. (2) Solar spectrum.

to the elements which produce them. To the substances recognised by Rowland, Messrs. Runge and Paschen† have added oxygen, the presence of which may now be considered as demonstrated (fig. 4), and Hartley and Ramage have added gallium.‡

Some thousands of the Fraunhofer lines, however, still belong to the category of "unknown" lines. Here, then, is a great field for further enquiry, for it is, perhaps, too early to conclude that these "unknown" lines have no terrestrial equivalents, or even that they represent the dissociated products of our terrestrial elements The latter view in fact appears to some extent negatived by the recent researches of Sir Norman Lockyer, which show that the first stage in the dissociation of a metal is indicated by the appearance of enhanced lines (lines which are brighter in the spark than in the arc spectrum), and in the case of iron and other well-known metals these enhanced lines probably do not appear as

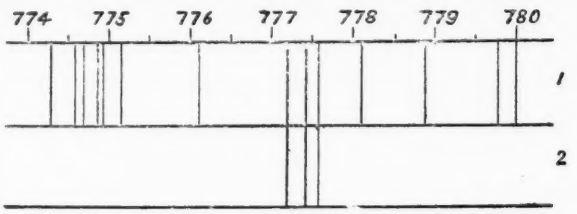


FIG. 4.—The lines of oxygen in the Solar Spectrum. (Runge and Paschen.) (1) Solar Spectrum. (2) Oxygen vacuum tube.

such among the dark lines of the solar spectrum. The substances which we can best compare with the Fraunhofer lines agree in indicating that the absorbing vapours which produce them exist under conditions very similar to those which exist in the electric arc. It may be, therefore, that some of the unidentified lines, which are mostly feeble, represent lines in the arc spectra of known substances which are so faint as to escape detection unless photographs are taken with very long exposures. In fact, the tables of lines recently published by Hasselberg, and by Prof. Rowland himself, for vanadium, chromium, and other elements, leave little doubt that many of the unidentified lines in Rowland's solar tables are to be accounted for in this way.

Another important point also appears to have received insufficient attention. It is by no means impossible that among the constituents of the earth's crust are many still unrecognised elements which exist in such small quantities as to evade the ordinary processes of chemical analysis, but which may yet be revealed to the delicate eye of the spectroscope. As the usual practice in the matching of solar lines is to deal with elements in as pure a state as possible, it would appear important to make a spectroscopic comparison with the sun of substances as they occur naturally in the form of minerals and rocks. Prof. Hartley has, in fact, already found that some of the rarer metals, especially lithium and gallium, are very widely diffused in mineral substances, and this furnishes an excellent illustration of the delicacy of the spectroscopic method. Until such mineral comparisons have been made, it would be unwise to suppose that all unidentified lines of the solar spectrum owe their origin to non-terrestrial matter.

In the investigation of the constituents of the sun, as already remarked, we are not limited to the dark line spectrum. The bright line spectra of the chromosphere and prominences may be examined any time the sun is visible, and by taking advantage of total eclipses, the outlying parts which constitute the corona are opened

* *Astrophysical Journal*, Vol. IV., 1896, page 324.

† *Astrophysical Journal*, Vol. IV., 1896, p. 318; Vol. VIII., 1898, p. 73.

‡ *Astrophysical Journal*, Vol. IX., 1899, p. 214.

to investigation. The photographs taken during recent eclipses, some of which are familiar to the readers of KNOWLEDGE, give very complete data as to chromosphere, prominences, and corona, and for our present purposes we may take these as including practically all that is certainly known of these appendages.

These photographs indicate that the chromosphere in its upper parts—five or six thousand miles above the photosphere—consists chiefly of hydrogen, helium, and calcium, while at lower levels we get indications of metallic substances in the numerous lines which constitute the so-called "flash" spectrum. As is now well-known, the flash spectrum is not a simple reversal of Fraunhofer lines; while the majority of the principal dark lines probably have corresponding bright lines in the flash spectrum, a great number of bright lines not represented with proper intensity by dark lines make their appearance (fig. 1). Sir Norman Lockyer has traced many of these bright lines to known substances, such as iron, titanium, and so on. He has shown that these previously "unknown" lines of the chromosphere spectrum are mostly lines which become intensified, or "enhanced," when we compare a spark with an arc spectrum of the same substance, and in the present stage of the inquiry it is supposed that the enhancement of these lines is due to the higher temperature of the spark. If we grant that the region which produces the flash spectrum is at a temperature higher than that which by its absorption produces the Fraunhofer lines, we not only have a pretty complete explanation of the origins of the lines, but we have a reason for the want of similarity between the flash and the Fraunhofer spectra. So far as there is any similarity between the two, it may reasonably be ascribed to the fact that the same substances are involved in the production of the dark and bright line spectra, and that many lines persist through a great range of temperature. But whatever may be the physical explanation, the discovery of the enhanced lines, aided by that of helium, removes a great deal of the supposed non-terrestrial matter from the chromosphere, and there is probably now no greater a percentage of unfamiliar lines in the chromosphere than in the solar spectrum itself.

The spectra of the prominences show that the substances present are the same as those which exist in the chromosphere, no additional elements being certainly indicated.

When we come to the corona, however, we have still to acknowledge ourselves in the region of the unknown. First and foremost in its spectrum is the green line which has, until quite recently, been known as 1474K, but which we now know to be much more refrangible than this line. Photographs taken at Viziadrug, India, in 1898, (fig. 1), show that while the bright 1474K line is truly chromospheric (Lambda 5316.79) and corresponds to an enhanced line of iron, that of the corona has a wave length 5303.7,* and has not yet been identified, unless Prof. Nasini's supposed new gas from Pozzuoli turns out to be its terrestrial equivalent. As to the other coronal lines which have been photographed during recent eclipses, no satisfactory evidence as to their origin is forthcoming, but the discovery of helium encourages us to hope that the coronal gases will be also eventually found upon earth.

In the present state of our knowledge it does not seem possible to give a perfectly trustworthy list of the elements certainly present in the sun. One published by Rowland, in 1891, is the most extensive, but the more recently published tables do not seem to afford complete justification for it. Taking the tables, however, and including oxygen, gallium, and the chromospheric and coronal gases, we may summarise the most probable elements as follows:—

Aluminium	Hydrogen	Potassium
Asterium†	Helium†	Scandium
Barium	Iron	Silicon
Cadmium	Lanthanum	Silver
Calcium	Magnesium	Sodium
Carbon	Manganese	Strontium
Cerium	Molybdenum	Titanium
Cobalt	Neodymium	Vanadium
Copper	Nickel	Yttrium
Coronium*	Oxygen	Zinc
Chromium	Palladium	Zirconium

In addition there is evidence which suggests the possible presence of the following elements:—

Beryllium	Mercury	Ruthenium
Didymium	Niobium	Thallium
Erbium	Platinum	Tin
Indium	Rhodium	Tungsten
Lead		

Besides these, Rowland, in his 1891 list, includes germanium and glucinum among the elements present, and iridium, osmium, tantalum, thorium, and uranium among those doubtfully present, while Lockyer concluded that lead and uranium were certainly present, and lithium, glucinum, rubidium, cæsium, and bismuth probably present.

It will be seen that the constituents of the sun approximate to those of our own earth, and Prof. Rowland was probably not far from the truth when he remarked some years ago that "were the whole earth heated to the temperature of the sun its spectrum would probably resemble that of the sun very closely." In each case our knowledge is fragmentary. Our terrestrial chemistry is but skin deep, and our solar chemistry is only that of the sun's atmosphere, for we as yet know nothing either of the interior of the earth or of the vast region which lies beneath the sun's photosphere. It must be borne in mind also that as regards the sun our knowledge is limited to the indications of the spectrum, which in the case of a mixture of substances may render no account of some of the elements present. Thus, although we are not yet in a position to assert that the composition of the sun is identical with that of the earth, it would not be easy to justify the view that there is any fundamental difference.

[For the use of figures 1 and 3 we are indebted to Sir Norman Lockyer, and for figures 2 and 4 to the editors of the "Astrophysical Journal."]

* *Roy. Soc. Proc.*, Vol. LXIV., p. 168.

* In corona only. † In chromosphere only. (Asterium and helium according to Lockyer, are the two constituents of the cleveite gas.)

"TREES STRUCK BY LIGHTNING."

By HOWARD B. LITTLE.

THROUGHOUT the past year correspondence has been carried on under the above heading in KNOWLEDGE It was in January last that "A. C." gave an account of an elm tree which had been practically shattered by the dread stroke; and he asked, "What actually takes place? What is the force exerted?" In the following month, again on the correspondence page, I answered these questions to the best of my ability, pointing out that our ascertained facts were few, but that electro-

lytic action, combustion, and violent evaporation were doubtless all present. I further suggested that the assistance of Botanists was required for the complete solution of the problems.

In the October number of KNOWLEDGE a most interesting letter from Baron Kaulbars was published. Here much detail was given concerning the fate of various trees, as also an account of the destruction of a stone monument which was, at intervals, braced internally by iron angles. But strangely enough the writer, in giving his conclusion (which, to save space I will write "steam"), altogether overlooks the terrific force in Nature—Electro-chemical action. Further, while he says that a very old dry tree may be burned down he seems to overlook the fact that the insulator resin is highly inflammable. Again, one finds it difficult to suppose that in the case of the tower the path of the lightning was from iron to iron. If however this was actually so, we are confronted with a remarkable difficulty to which I shall refer later.

Next, in November last, Lord Hampton, after endorsing the statements made by Baron Kaulbars, states that upon one occasion (of which details are given), Faraday, pronouncing upon a smitten tree, asserted that the lightning had gone down the hollow stem and, meeting with damp at the bottom, generated steam, so causing an explosion. Now, with all deference, I would submit that there appears to be an error here. Faraday knew well enough that the resistance of air is enormously higher than that of any wood. By air I mean of course air at more or less normal pressure. Why then did the lightning seek the path suggested? We must regard trees as being in a measure lightning conductors. This brings me to the undeveloped argument suggested by the case of the tower which Baron Kaulbars mentioned. Did the lightning follow a track (which was in all probability tortuous) through each piece of iron, going always from one to that next it? I doubt it. But of this more anon.

A few days since the Editors handed me two letters which they had received recently upon this question. The first, signed E. W. Mitford, gives very many instances of trees having been struck. His first case is that of an Elm, and the damage done he describes as having been via "several serpentine channels through the bark, and reaching half way up the tree from the ground." Now this serpentining is not difficult to account for (it was mentioned in October), the fact being that the current goes from point to point by the easiest route. But why the suggestion of "from the ground"? The idea of return shock, or earth's potential is difficult of conception here. A tree may easily enough be struck. first, half way up its height, and further, there cannot be much doubt that the trees are less susceptible to damage (of a serious nature) at their tops. The same correspondent remarks that he has frequently seen lightning rise in a tapering pillar from the earth. This is no doubt the so called "Luminous Rain." Oh that I had space to deal with it here!!

The next letter is that of "An Old Rug." May his hearth never grow cold!! He, dating from Jamaica, tells how the top of a tree was taken off and carried away with tremendous violence. The branches too were cut off and strewn round a hole in the earth where the root had been. (I want in this connection one detail—was the hole lined with earth in its normal condition, or was there a sleeve of vitrified sand?) The trunk of the tree was completely shattered. That is to say here again the top was only injured by removal.

Finally, in the December issue, P. de Jersey Grut gave particulars of a case which is perhaps more interesting than any yet cited. In this instance the tree struck was encircled by a rope some twenty-five feet from the ground, and it so chanced that an end of the rope stood out from the bark of the tree, so that during the earlier part of a rain-storm the tree was damp from the top to the rope, while the lower portion of the trunk was kept comparatively dry. The tree in this condition was struck, the lower part only being damaged. And the damage followed, downwards, a path which the twist in the fibre of the wood made easiest.

And now, endeavouring to gather up those thread ends which I am painfully conscious of having scattered; the methods of lightning seem erratic. The word "chance" is all too often misunderstood; it really means the natural effects of causes which were unexpected, or even unknown. And lightning moves at a speed that is literally beyond our ken, save for figures which convince only the few.

From all this then, I propose, in conclusion, to venture upon one or two bold statements. Suppose an enormously powerful magnet to have been erected, several feet above a building, and further suppose that the surrounding air be filled with flying masses of steel moving "like lightning." What would be the result? Would the steel that came near go to the magnet? Some might, but, remembering the pre-supposed (lightning) velocity many of these masses would swerve from their paths if they were sufficiently near, and go crashing through the roof. In other words, a lightning conductor may often bring destruction just near enough to destroy that which it has been set up to protect. And a tree top may bring the lightning to its own immediate neighbourhood, yet, not quite to itself, so that it is not extraordinary if the tree be struck in the middle.

I am painfully conscious that I have not done justice to my subject. But, as a lightning conductor, I seem to have drawn towards me a vast deal of (may I say matter?) with which I cannot deal. Careful observation, and well recorded data are still at a premium.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

"IS THE STELLAR UNIVERSE FINITE?"

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In his interesting papers on the above subject in KNOWLEDGE (July and November), Mr. Burns has neglected three factors which, I think, must be taken into consideration. These are (1) the absorption of light by our atmosphere, and (2) by our object-glasses or mirrors, and (3) the finite sensibility of our eyes and photographic plates.

Suppose for a moment that all stars consists of two degrees of intrinsic brightness, their differences in photometric magnitude being otherwise due to differences in distance, and that stars are uniformly distributed through space. Then with a given aperture we are able to see every star within a sphere the radius of which is equal to the greatest distance at which a star of the second (the fainter) degree of intrinsic brightness can only just be seen by reason of the three factors mentioned. Outside this sphere we have a

shell the external limit of which is the maximum distance at which a star of the first degree of intrinsic brightness is just visible, and within this shell only stars of the first degree of intrinsic brightness will be visible with the same aperture. But will an increase of aperture render visible all the stars of the second degree of intrinsic brightness, i.e., all the stars lying within the shell? It will not, because some of the stars—viz., those near the outer surface of the shell—will be so faint that their feeble rays will be either entirely absorbed, or so much absorbed by our atmosphere and telescope, that the limited sensibility of our eyes or photographic plates will be unable to show them. But it may be argued that these second degree stars may be bright enough to be seen with the larger aperture even from the outer surface of the shell. This may be true in the limited case we are considering, but not when we consider infinity.

In all probability stars consist of 100 or 1000 degrees of intrinsic brightness. We must therefore consider 100 or 1000 shells around the inner sphere, in each succeeding one of which, with a given aperture, fewer stars are seen. If the feeble rays from a star of the 100th degree of intrinsic brightness be just able to penetrate our atmosphere from, say, the 50th shell, then all the 100th degree stars beyond this distance will be quite invisible with any aperture. Stars of the 100th and 99th degrees of intrinsic brightness will be visible beyond the 51st shell; those of the 100th, 99th, and 98th degrees beyond the 52nd shell, and so on till we come to the 150th shell, where stars of the 1st degree of intrinsic brightness become invisible, and which therefore forms the limit of the visible stellar universe. Must we not, then, expect a thinning out of faint stars somewhat similar to that shown in fig. 2, p. 154 (July)? And may we not therefore brush away those "clouds of cosmical dust which conceal eveything beyond" our faintest stars?

But, even disregarding absorption altogether, is the question of sky-light from an infinite number of stars so simple as Mr. Burns assumes? Someone has defined "nothing" as "a bung-hole without a barrel"! Similarly, a star at infinite distance is a star without a magnitude. For if it be at infinite distance it must be infinitely faint, and its disc infinitely small, i.e., like a geometrical point, without magnitude. How, then, can an infinite number of such points cover anything at all, much less the entire sky? And again, could the light of a star at infinite distance ever reach us? Would not the star be at a finite distance if it did? Nor will the excessively faint stars that are at finite distances produce any apparent brightness, for the image of each star falls upon a different point of the retina; and since each is invisible, they will be collectively invisible.

Must we not therefore conclude that although the stellar universe may be infinite, the visible portion of it must be finite; and that no reasoning, from numerical data or otherwise, can ever advance us a step further?

It seems to me that the question is not "Is the stellar universe finite?"—that we can never know—but "Is it probable that within the finite visible universe stars are uniformly distributed?"

Madeira. WM. ANDERSON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Having read the article in last month's issue under the above heading, it occurred to me that the writer, Mr. Burns, would go a good way in answering the question if he were to define in what sense he uses the word "infinite."

When scientists speak of the number of the stars being infinite, they either mean indefinite, or give to the word its strict philosophical meaning. Taken in the first sense the word infinite is quite intelligible as applied to the number of the stars, man's power of observation being so limited. To adopt the second sense is to put forward an absurdity.

It is scarcely necessary to observe that the idea of infinity in the strict sense does not admit of circumscription; of either increase or decrease; and accordingly excludes the idea of extension or multitude.

Surely this sense of the infinite cannot be predicated of the stellar universe, made up as it is of units.

R. J. CONNELL.

[Mr. George H. Hill (Streatham), writing on this subject, "Is the Stellar Universe Finite?" challenges Dr. Burns' conclusion (KNOWLEDGE, November, 1899, p. 249), that "if the number of stars were infinite we should have the whole sky one blaze of light," on the ground that Dr. Burns assumes that what is lost in stellar radiation by distance, is gained in number. He writes:—"But if the illuminating area were to decrease owing to increase of distance, more rapidly than it increased, owing to greater numbers, surely however infinitely the process might be continued it would never give us a blazing sky." This is of course true if the rate of decrease be sufficiently high, and simply expresses in other words my own criticism of Dr. Burns' fourth hypothesis. Mr. Hill gives my suggestion more at length, and conceives of space "as containing practically isolated stellar groups or systems (on a colossal scale), every star visible to us belonging to but one such system, while other (exterior) systems appear to us only in the form of nebulæ." He further suggests that there would naturally be a tendency to thin out towards the margin of such a system, in accordance with Mr. W. H. S. Monck's remark (KNOWLEDGE, August, 1899, p. 179) that "a thinning out commences at (comparatively speaking) no great distance from the earth or sun." It must be borne in mind that the idea that the irresolvable nebulæ were "external galaxies" was refuted long ago by Herbert Spencer, Proctor, and others. The clustering of nebulæ round the poles of the Milky Way is a clear proof that they form an integral part of the same structure with it; as their occurrence with stars in the Nebecula Major is a proof that they exist at substantially the same distances from us, as do the stars.]

THE "SEAS" OF THE MOON.—Mr. James Macgeorge criticises Mr. J. G. O. Tepper's paper on "The 'Seas' of the Moon" (KNOWLEDGE, November, 1899, p. 251), on the ground that Mr. Tepper has not shown that the Moon ever had an atmosphere sufficiently dense to support any form of organic life, and calculates the amount of atmosphere which it would have possessed had it attracted to itself a proportion of atmosphere, as compared with that of the earth, corresponding to its gravity. As the figures may be of some little interest I give them here more precisely than Mr. Macgeorge has done. Taking the diameter of the earth as 7,926 miles and of the Moon, 2,160 miles; we have the earth 3.67 times the Moon in diameter, or 13.47 times in surface area. Its mass, however, is 78 times as great. If then the total mass of the earth's atmosphere be 78 times that of the Moon we shall have 5.8 times the

amount of atmosphere above each unit of the surface here, that there is on the Moon. But this atmosphere will be differently distributed. Half of our atmosphere is passed through when we ascend 3½ miles from the earth's surface. To pass through half the Moon's atmosphere we should have to ascend 23 miles. At 10½ miles therefore above the surface of the two worlds we should find the same amount of atmosphere above us in both cases, and at 21½ miles the actual density of the atmosphere would be as great for the Moon as for our earth, though at the surface of the ground the pressure at the earth's surface would be 37.6 times as great as on the Moon. Above 21½ miles high the entire advantage would rest with the Moon. Now the earth's atmosphere is sufficiently dense far higher than this to vaporize meteors by the resistance which it offers to their path, and to produce strong crepuscular effects. We have no evidence of an atmosphere approaching this in efficiency, on the Moon. It seems clear then, that the Moon has not, at present, the proportion of atmosphere to which its mass entitles it. If it never had more than at present we must agree with Mr. Macgeorge that "the theory of vegetable remains necessarily falls to the ground." But seeing how little we know as to the condition and extent of the earth at the time when the lunar crust had become solid and cool, or of the distance apart of the two bodies at the time, it is certainly rash to say that the Moon may not then have had a respectable atmosphere. As to what has become of it since, we most certainly cannot agree with Mr. Macgeorge that "it is impossible that it may have been attracted by the earth," nor is it "inconceivable that it may have been absorbed by the substance of the Moon." Neither hypothesis is, however, necessary, for Dr. Johnstone Stoney's researches tend to show that the Moon has not sufficient attractive force to retain permanently an atmosphere of constituents similar to those of our own; and assuming that the Moon once had a comparatively dense atmosphere, this would necessarily fully explain its present disappearance.]

[COLLECTING METEORIC DUST.—Messrs. T. S. Overbury and L. B. Booth enquire how the Rev. J. M. Bacon collected meteoric dust by means of gun-cotton during his recent balloon voyage to observe the Leonids. The answer is of the simplest. A continuous current of air was drawn through a tube in which a small plug of gun-cotton was fixed, which would act as a filter to filter out any dust which it might contain. The gun-cotton could easily be dissolved at the end of the voyage, and the amount and character of the dust which it had taken up, if any, be ascertained.

[E. WALTER MAUNDER.]

ACIDS IN SOIL.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Will you be so good as to inform me if there exist in any part of England or Ireland marshy soils, or rather mineral moors, which contain besides sulphuret and peroxide of iron:—organic acids such as formic acid or acidity, and if so in what proportion to the other ingredients.

South Tottenham, W. A. SMITH.
Dec. 12th, 1899.

Obituary.

Sir J. WILLIAM DAWSON, whose death on 19th November, 1899, we regret to record, was a leading man of science of the old school—a teacher who stoutly supported the final destiny of man as taught in Revelation, and emphatically opposed to all theories of the evolution of man from brute ancestors, nor would he allow anything more than a moderate antiquity for the species. Of Scottish extraction, he was born at Pictou, Nova Scotia, in 1820, obtained the degree of M.A. at Edinburgh in 1842, then recrossed the Atlantic, and spent some time in scientific exploration under Sir Charles Lyell's direction. Papers contributed to the Geological Society of London soon brought him into prominence. In 1855 he was appointed Principal of McGill University, Montreal, only excelled in America by that of Harvard, and the scientific side of that institution was practically Sir William's creation. The Royal Society of London in 1862 elected him a fellow, and twenty years later he received the Lyell Medal of the Geological Society of London. In 1884 he was made a K.C.M.G., in 1886 he discharged the duties of President at the Birmingham Meeting of the British Association, and he was the first President of the Royal Society of Canada. Eozoon Canadense, described by him in 1865, opened a controversy on organic life which is not yet entirely disposed of. The study of Geology he would have "delivered from that materialistic infidelity which, by robbing nature of the spiritual element and of its presiding Divinity, makes science dry, barren, and repulsive." "Modern Science in Bible Lands," "Eden Lost and Won," among his many popular books, indicate the trend of his teaching. Sir William's solid contributions to science in the form of papers to learned societies, periodicals, and magazines, were very numerous, those to our own Royal Society numbering one hundred and fifty-eight.

Sir HENRY TATE, whose death occurred on the 5th December, 1899, will be remembered as a successful man of business who utilised his great wealth in promoting the interests of science and art. "This gallery and sixty-five pictures were presented to the nation by Henry Tate for the encouragement and development of British Art, and as a thank-offering for a prosperous business career of sixty years." So reads an inscription affixed to the base of a column in the vestibule of the magnificient pantheon of Art on the banks of the Thames erected on the site of Millbank Prison. Sir Henry endowed many scholarships, contributed £10,000 to the building fund of Owen's College, and donations to the extent of some £50,000 to University College, Liverpool. Born at Chorley, Lancashire, in 1819, he served an apprenticeship to the grocery trade, and subsequently engaged in sugar refining—a business which, under his shrewd management, rapidly expanded to gigantic proportions, and "Tate's cube sugar" became a familiar object all the world over. As his wealth augmented he freely utilised it in the stimulation of education and in patronising artists. Previous to the opening of the Academy Exhibition each year he gave a great dinner at Park Hill, Streatham, to the leading artists, and in course of time he acquired by purchase a collection of the works of British Artists of the day, which gradually led him up to the idea of forming a permanent home or Gallery thoroughly representative of British Art. He offered £80,000 to build a gallery, provided the Government would give a site. Vacant land near the Embankment at Blackfriars was declined

by the City Corporation, and a site at South Kensington had already been promised for a new science college and museum, but, at last, Sir William Harcourt, in 1892, then Chancellor of the Exchequer, offered the site at Millbank. The Tate Gallery was opened 21st July, 1897, and so recently as 27th November, 1899, the opening of a new wing completed the great building which British Art owes to Sir Henry Tate's munificence.

Science Note.

ROYAL INSTITUTION.—The following are the Lecture Arrangements at the Royal Institution before Easter:—Mr. C. Vernon Boys, Six Christmas Lectures (especially adapted for young people) on Fluids in Motion and at Rest; Professor E. Ray Lankester, Twelve Lectures on The Structure and Classification of Fishes; Dr. W. H. R. Rivers, Three Lectures on the Senses of Primitive Man; Professor H. H. Turner, Three Lectures on Modern Astronomy; Dr. Charles Waldstein, Three Lectures on Recent Excavations at Argive Heræum (in Greece); Three Lectures by Sir Hubert H. Parry; Mr. W. L. Courtney, Three Lectures on The Idea of Tragedy in Ancient and Modern Drama; The Right Hon. Lord Rayleigh, Six Lectures on Polarised Light.

Notices of Books.

Handbuch der Astronomische Instrumentenkunde. A description of the instruments used in astronomical observations, together with an explanation of their construction, their application, and their mounting, on fundamental principles. By Dr. L. Ambronn. Two volumes, containing 1185 figures in the text. (Berlin: Julius Springer. 1899.) Dr. Ambronn has produced a work which is unique of its kind, and which will, beyond doubt, be regarded as classic. From time to time our great instrument makers in England have published catalogues of their telescopes and mountings, and perhaps a full description of their properties and the methods of making and adjusting them, but these cannot for a moment compare with the encyclopædia of instruments and instrumental adjuncts that has just been compiled by Dr. L. Ambronn. In Germany, Carl wrote, about 1860, his "Principien der Astronomischen Instrumentenkunde," and, twenty years later, Von Konkoly his "Anleitung zur Ausführung Astronomischer Beobachtungen"; and, quite lately, Professor E. Becker has produced a monograph on the "Mikrometer"; but these may be regarded as simply introductory to Dr. Ambronn's work. The two volumes contain together some 1276 pages, and are divided into seven chapters. The first chapter treats of the adjuncts of an astronomical instrument—screws of all sorts, both for clamping, for correcting and motion, and for measuring; plummets and levels; artificial horizons, collimators and verniers, and reading microscopes. All these are very copiously illustrated; and Dr. Ambronn has not confined himself to a mere description of them by word or woodcut, but discusses their properties, their errors, and the necessary corrections for these, whether by mathematical or by instrumental means. The second chapter takes up the question of the recording and noting of time, whether by clock or chronometer, by pendulum, hair-spring, or electric control; the regulation of motion and compensation. Chapter three is divided between three large subjects. The first has to do with the axes of a telescope, and the supports on which they rest or in which they turn. The second division takes the two great forms of instrument with which telescopic work may be done—the refractor and the reflector. In the case of refractors, there is a very full description of the manner of choosing the glass, the grinding and figuring of the lenses, and methods of combining the lenses of different glass and different form to make the finished objective. The mounting of the objective in its cell is not omitted, nor the effect of the whole on the form of the stellar image. The methods of figuring and polishing, or silvering the mirrors, and the different forms of reflecting telescopes, are fully described. The third division tells of the constructing and dividing of the circles and of the determination of their errors, and several pages are devoted to clamps and slow motions. The fourth chapter, of 120 pages, takes the micrometer in all its forms, from the simplest focal micrometer to the great Radcliffe and Repsold heliometers. It is a very great gain that these important instruments are so fully figured. The next two chapters—comprising nearly the whole of the large second volume—consist of descriptions of the important instruments of the world, which are remarkable for their size and power, or for their perfect or ingenious form of mounting, or for their adaptation to some particular object. We find here the photometers of the Harvard Observatory, of Steinheil, Knobel, and Pritchard; the measuring apparatus of Kapteyn; the meteor camera of Elkin; the great refractors of Yerkes and Lick; the elbow form of mount in use at Potsdam; the twin telescopes of Greenwich; the great reflector of Dr. Isaac Roberts. Incidentally, Dr. Ambronn mentions that the chief reflectors are made and used in England, the exceptions being those of Professor Safarik, at Prague, and of the well-known optician, Dr. H. Schröder. The final chapter is devoted to the housing of the telescopes. Pretty nearly every sort and shape of dome is figured and described. The omissions are very few and slight. We are sorry not to see any description of the properties, or use for astronomical purposes, that the portrait lens has been put to by Professor E. E. Barnard and others. There are, also, one or two special forms of photographic objectives which apparently are not described—notably a very short focus portrait lens by Voigtländer and Sohn, and Mr. J. H. Dallmeyer's stigmatic lens. Perhaps the section which is the least completely dealt with is that of the spectroscope, which is at once one of the most intricate and one of the most important of the telescope accessories. The objective-prism, in particular, is very briefly treated of. But these are but small points, and cannot detract from the immense value of the book as a whole. It will form an invaluable adjunct to the library of every observatory—for the whole wide field of astronomical instruments has been covered with conspicuous skill, thoroughness, and care—and it will be a complete reference book to any astronomer who wishes to establish a telescope of his own, even though his equipment be necessarily a modest one.

The Natural History of Selborne. By Gilbert T. White. Edited with Notes by Grant Allen. (John Lane.) Illustrated. XII. Parts. 1s. 6d. each. It is pleasant to think that among the last literary work undertaken by the late Grant Allen was the editing of an edition of White's classic letters. That this was a most congenial task to Grant Allen we are certain, for he knew the neighbourhood of Selborne well, and was a great admirer of the immortal Gilbert White. Although—as the editor says in his delightful introduction to the volume—these "letters have probably been reprinted in a greater number of editions than those of any other English worthy," nevertheless their present edition is very welcome. The aim has been to preserve the original text; and the editor's notes, which are useful and not unnecessarily frequent, are always signed, and can, therefore, be immediately identified. No attempt has been made to bring all White's statements up to the modern standard of scientific knowledge—and rightly, for such a gigantic task would utterly spoil the book. Everything in this edition—from the editor's scholarly introduction to the excellent pen-and-ink drawings by Mr. Edmund H. New—is in keeping with the character of the letters. An appendix contains a novel feature in some interesting marginalia from Samuel Taylor Coleridge's copy, as well as a complete bibliography of the work.

Bacteria. By George Newman, M.D., F.R.S. (Murray.) Illustrated. 6s. Dr. Newman, according to the preface in this book, had no other inspiration than an editor's request "to set forth a popular scientific statement of our present knowledge of bacteria," when he undertook to add one volume more to the large number already in existence. With this sort of halter round one's neck it is a hazardous task to traverse the uneven ground covered by that now all-embracing, yet innocent looking, word—bacteria. As the author says, "it is difficult to escape the Scylla and Charybdis in such a voyage." Too technical for the many and too popular for the few, one or other of these results is often arrived at in efforts of this kind. A medical student, in his third or fourth year, would follow Dr. Newman with profit, but the average man, depending upon common sense

XUM

and *minus* the buoyant auxiliaries of science, could hardly sustain the voyage from cover to cover. The word "popular" can hardly be applied to a book in order to understand which the reader must know the nomenclature of the chemist, the phraseology of the dissecting room, and the out-of-the-way language of many other specialists in different domains of science.

Curiosities of Light and Sight. By Shelford Bidwell, F.R.S. (Sonnenschein.) Illustrated. 2s. 6d. Consists mainly of matter presented in the form of lectures at various places, but here remodelled for a larger public. Of a popular and informal character, as might be expected in such a case, the essays, as we may now call them, bring into relief such phenomena as defects of the eye, optical illusions, curiosities of vision, and so on, subjects which appeal more particularly to the spectacled section of the community. Heavily leaded type is used, and a fair-sized volume is thus eked out of an almost starvation supply of intellectual food.

Views on some of the Phenomena of Nature. Part II. By James Walker. (Sonnenschein.) 2s. 6d. Our author has selected for his theme all the inexplicables—force, motion, space, ether, light, heat, electricity—and courageously attempts to fly in this attenuated atmosphere, so to speak. One needs to be very wide awake in order to glean a little mental food here and there in this arid desert; but now and then it is possible to drop across an oasis—fertile, refreshing, new. For example, "light and the sun's photosphere are one," "light is the sublimed product from matter in an incandescent state," and light is "projected into space by some disruptive force developed on the sun's surface."

Sport in East Central Africa. By F. Vaughan Kirby (Maqaqamba). (Rowland Ward.) Illustrated. 8s. 6d. This book, dealing with several hunting trips in the wilds of Portuguese Zambesia and the Mozambique Province, is full of the most stirring incidents connected with big game shooting that can well be wished for, told in the most matter-of-fact way imaginable. It is not to be inferred from this that the author has been guilty of giving us "travellers' tales," or even of stretching a point; indeed, we believe every story he tells. And as to his matter-of-fact style, we admire it, and think that it adds very greatly to the interest of the book. It is, in fact, the style—a rare one—in which all books of big game shooting should be written. That Mr. Kirby is a true sportsman—and not a wanton destroyer of animal life—and a brave and resourceful man to boot, is testified by many a page of his engrossing and exciting narrative. A very useful appendix to the book contains interesting and informing field notes on all the larger animals—and there are many—obtained by the author in the region of which the work treats. We heartily recommend the book not only to sportsmen, but to those who are in any way interested in East Central Africa, for the author knows the country and its people well, although, perhaps, his knowledge of them is not so intimate as that of the wild animals for the hunting of which he has lived.

The Social Life of Scotland in the Eighteenth Century. By the Rev. Henry Grey Graham. Two vols. (A. & C. Black.) 24s. To draw an indictment against a nation has always proved at once an easy and a popular task, no matter how poor the grounds of the charge, or how remote from the facts. There are few people in the world who have suffered more odium in this way at the hands of the impecunious scribbler than the race across the border. But Scotland has incurred a lasting debt of gratitude to the author of these fascinating volumes for the comprehensive acumen with which he has exploited the records of the past, placing in our hands a delightfully vivid picture of Scottish life and Scottish manners in the last century. Mr. Graham has essayed to give us history in its most instructive form—to bring before his readers the life of the whole people, rich and poor, lairds and labourers, as they lived it. The goal which he has set himself is the worthiest in the historian, and our author has justly followed his course to the end. "It is in the inner life of a community that its real history is to be found—in the homes and habits and labours of the peasantry; in the modes and manners and thoughts of society; what the people believed, and what they practised; how they farmed, and how they traded; how the poor were relieved; how their children were taught, how their bodies were nourished, and how their souls were tended." Thus the task. But at what infinite pains of research, of sifting and sorting, of weighing and counting, has that task been accomplished. Apart altogether from the great reach and number of the authorities consulted, what countless documents, letters, bills, pamphlets, and kirk session records have been laid under contribution, as these entrancing glimpses of that far away time are unfolded before us. Not the least among the virtues of the work is the thoughtful orderliness and compactness of the picture as a whole—the artistic limning of that peaceful revolution which brought the impoverished country and people onward and upward in every channel of national activity. If it be not invidious to single out any portion of a book in which we have not found a dull page, we may be permitted to direct attention to the chapters on The Land and the People, on Education in Scotland, and to the happy and entertaining account of Town Life in Edinburgh. In this latter chapter the author realises most vividly the later period of the greatness of the old town, in whose dark recesses, Lord Rosebery has told us, are embodied three-parts of the history of Scotland—when the High Street was the daily meeting place of judges, ministers, and advocates, when lords of Session resided in the Canongate, and resorted at night to the Crochallan Club, so famous for its association with Burns, or might be found at John Dowie's tavern. We do not know a better account of this intensely interesting chapter in the life of Auld Reekie. In taking a regretful leave of Mr. Graham's book, which is sure to become a standard work in Scottish history, we can but hope that the unique success which has crowned his labour in the preparation of these two volumes, may induce him to write the necessary third volume on the Literature and Fine Arts of the Century, for which he must have amassed a quantity of material. Without such a volume the work is scarcely complete.

Star-land. By Sir Robert Stawell Ball, F.R.S. (Cassell.) 7s. 6d. It almost makes one long to be a child again, and to have the right to form one of Sir Robert Ball's audience at his Christmas lectures at the Royal Institution, to read the new edition of "Star-land." Sir Robert has a charm of style and a gift of words that go far to make the hard things of astronomy easy, and the abstruse problems plain; and where there is a bit of the way of knowledge that seems dull or uninteresting, he has an anecdote or an illustration that carries one over the dreary part with a rush. The very largest part of the book tells of that portion of the stellar universe which is comprised within the limits of the solar system; and, perhaps, it is a slight indication of Sir Robert's Hibernian origin that has led him to adorn the cover of "Star-land" with a very beautiful golden representation of the corona and comet of 1882. Speaking of coronæ, it is just a little bit of a pity—after Sir Robert Ball has explained to the children that the size of an object depends very largely on its proximity, and that very serious consequences would result to the temperature of the earth if it was brought closer to the sun—that, on p. 40, in Trouvelot's drawing of the eclipsed sun of 1883, he should have brought it so alarmingly near. The original representation in "L'Astronomie" was considerably exaggerated, but Sir Robert's copy is like Creusa's ghost in Virgil's description, *nota major imago*. There is one point on which Sir Robert Ball speaks with assurance, but on which we have not been able to gather any direct or first-hand evidence. On p. 57 he has a representation of a man standing inside and at the base of a very tall chimney, and below is the description, "How the stars are to be seen in broad daylight." Is it really so, and how many stars, and of what magnitude, can be seen thus?

Colour: A Handbook of the Theory of Colour. By George H. Hurst, F.C.S. (Scott, Greenwood & Co.) Illustrated. 7s. 6d. Artists, dyers, calico printers, and decorative painters, who are accustomed to use pigments in their everyday work, will find in this book a valuable compilation on matters concerning every phase of colour—its production by the decomposition of light, theories of colour phenomena, physiology of light, contrast of tone, decoration and design, and measurement of colour, or the expression of different tints by numbers so that any given shade of colour can be reproduced from data preserved in notebooks or received from other sources. Some excellent plates largely augment the value of the work.

Wild Life in Hampshire Highlands. By George A. D. Dewar. (Dent & Co.) Illustrated. 7s. 6d. This is one of the handsomely bound and luxuriously printed volumes of the Haddon Hall Library now being issued under the editorship of the Marquess

of Granby and Mr. Dewar. The Hampshire Highlands lie in the north-west corner of the county, a part little known to the tourist. The author's pleasantly written description of the spot he loves so well, and his engrossing account of the many country pleasures to be enjoyed there, makes one wish to visit the district. Although there is perhaps nothing new in the author's observations, we have derived much peaceful pleasure in the perusal of the well-told experiences, anecdotes, and observations of this keen field naturalist and sportsman. The illustrations are like the letterpress—restful and most soothing.

Chats about the Microscope. By Henry C. Shelley. (Scientific Press, Ltd.) Illustrated. 2s. A little book intended to enlist the interest of aimless pedestrians in country places who sacrifice the pleasure and instruction contained in every mossy bank, every darkling pool—the happy hunting-ground freely accessible to all who will but avail themselves of the key to Nature's precious casket. The book is but a slender introduction to pond life, diatoms, foraminifera, and a few other kindred subjects; lacking the sequence necessary as a basis of pure scientific study, it is better adapted as a guide in using the microscope incidentally as a source of innocent amusement. The illustrations are anything but attractive—the "porous cells of mosses," for example, figured on p. 60, look as stiff and mechanical as if intended as a working drawing for the making of book-shelves.

Darwinism and Lamarckism. By F. W. Hutton, F.R.S. (Duckworth & Co.) 3s. 6d. net. Apparently this book consists of a verbatim report of four lectures delivered, in part, as far back as 1887. A great part of the old ground is traversed once again, and little, if any, additional light is shed upon the all-absorbing subject. What is new may be termed the bearer of the candlestick, Mr. Hutton himself, who contrives to project the luminous rays into the holes, corners, and crooked by-ways of the fabric raised by Darwin, Lamarck, and the thousand-and-one workers who have followed in the footsteps of these illustrious pioneers. The best we can say of the book is that it is a handy bird's-eye view of evolution in the wider sense of that term.

Common Sense Health Reform. By T. Thatcher. With supplementary article on "The Gospel of the Open Window," by the Hon. Auberon Herbert. (Simpkin, Marshall & Co.) 2d. Mr. Thatcher is a hero, we know, and not alone because Mr. Auberon Herbert has told us so; but we are not quite sure that a calm consideration of the long vista of trapeze bars, horizontal bars, stirrups and rings, punching balls, and divers developers which Mr. Thatcher opens up before us, will not be held to constitute him a martyr as well. But his efforts are made in the best of good causes—that of robust health; and we heartily commend this description of his experiences to all in search of health guidance.

On the Utility of Knowledge-making as a Means of Liberal Training. By Professor J. G. Macgregor, of Dalhousie College, Halifax. (Nova Scotia Printing Co., Halifax, N.S.) We are obliged to Professor Macgregor for sending us a copy of his informing inaugural address on a subject of so much interest to KNOWLEDGE.

We have received Messrs. T. Cooke and Sons' illustrated catalogue of telescopes, transit instruments, spectroscopes, chronographs, micrometers, driving clocks, observatories, and other astronomical and scientific instruments. As is well known among practical workers, there is now a tendency among some makers of these instruments to lower prices at the expense of quality in workmanship, but this firm proceeds on the principle that "it is impossible to do good work at the cost of bad," and many, as we can testify, know this truism only too well.

We are glad to receive the new edition of Mr. Mee's "Heavens at a Glance." This handy little almanac—printed on one side of a card for observatory use—has been prepared for 1900 on the same lines as for 1899, and will be found a valuable and convenient guide to observers. The data for meteoric showers have been taken from Mr. Denning's list in "Observational Astronomy," for variable stars from information supplied by Sir Cuthbert Peck, Mr. J. E. Gore, and Mr. J. Grover, and the rest from the "Nautical Almanac."

Early in the new year Mr. John C. Nimmo will publish the first volume by Prof. Sayce, of Oxford, of "The Semitic Series," a new series of handbooks, intended to present compactly and in popular form a knowledge of the more important facts in the history, religion, government, language, customs, etc., of the Babylonians, Assyrians, and allied Semitic races of ancient history.

BOOKS RECEIVED.

Memory Training: Its Laws and their Application to Practical Life. By Christopher Louis Pelman. (70, Berners Street.)

Common Sense Health Reform. By T. Thatcher. (Simpkin.)

On the Utility of Knowledge-Making as a Means of Liberal Training. By Prof. J. G. Macgregor.

Teleography. By Thomas R. Dallmeyer, F.R.A.S. (Heinemann.) Illustrated. 15s. net.

The Christmas Bookseller, 1899. (Whitaker.) 1s.

The Advance of Knowledge. By W. Sedgwick. (Allen.) 6s.

The Boyhood of a Naturalist. By Fred Smith. (Blackie.) 3s. 6d.

Englishwoman's Year Book, 1900. (Black.) 2s. 6d. net.

Who's Who, 1900. (Black.) 3s. 6d. net.

Science and Faith. By Dr. Paul Topinard. Translated by Thomas J. McCormac. (Kegan Paul.) 6s. 6d. net.

A First Book in Organic Evolution. By D. Kerfoot Shute. (Kegan Paul.) 7s. 6d.

The "Mechanical World" Pocket Diary, 1900. (Emmott.) 6d.

Makers of Modern Prose. By W. J. Dawson. (Hodder and Stoughton.) 6s.

Co-ordinate Geometry—The Conic. By J. H. Grace, B.A., and F. Rosenberg, M.A. (Clive.) 4s. 6d.

Twelve Months' Notes on Birds in the South Hams District—(August, 1898–99). By E. A. Savage Elliot.

Letters of Faraday and Schoenbein, 1836–1862. Edited by Kahlbaum and Darbishire. (Williams and Norgate.) 13s. net.

The Mind of the Nation. By Marcus R. P. Dorman, M.D. (Kegan Paul.) 12s. net.

The Story of the Wanderings of Atoms. By M. M. Pattison Muir. (Newnes.) 1s.

Useful Arts and Handicrafts Series:—Picture Frames by Novel Methods. Dyes, Stains, and Inks. Decorated Woodwork and Wood Carving for Beginners. (Dawbarn & Ward.) Illustrated. Each, 6d. net.

Whitaker's Almanack, 1900. Whitaker's Peerage, 1900.

The Races of Man. By J. Deniker, SC.D. (Paris.)

Contemporary Science Series. Walter Scott. Illustrated. 6s.

Optical Activity and Chemical Composition. By Dr. H. Landolt. Translated by John McCrae, PH.D. (Whitaker.) 4s. 6d.

Monthly Star Maps for 1900. By W. B. Blaikie. (Scottish Provident Institution.)

Social Chess. By James Mason. (Horace Cox.)

The Studio. December. 1s.

THE BLACK RAIN OF AUGUST 6, 1899.

By Major L. A. EDDIE, F.R.A.S.

ON August 14th, 1888, a heavy fall of black rain (an account of which I published in the "Grahamstown Journal," of August 28th, 1888) took place in Grahamstown and the surrounding districts, extending over an area of more than 360 square miles, when I advanced several theories in an endeavour to explain the cause of this curious phenomenon; but no microscopical examination of the water itself was made on that occasion. During the early part of the month of August, in many of the intervening years since this recorded fall, there have been similar downfalls of blackish rain, though less pronounced, which have been either observed by myself or reported to me by others.

The fall in August, 1888, was heralded by an almost incessant low rumbling thunder, and, in like manner, the fall of black rain on the early morning of Sunday, the 6th August, 1899, which I have now to record, was preceded by a continuous bombardment of muffled growling thunder varied by one smart deafening peal. This storm followed after two days of a stiff south-easter. The storm, accompanying rain, and the corresponding time of the year, to my recollection agreeing with that of August, 1888, induced me to inspect the water that had fallen, when I was not surprised to find the colour and appearance of the fluid to resemble that of the previous August, viz., to be of a sable tint as if mixed with ink. On putting by some of this dusky fluid in a white enamelled vessel, I soon observed that the liquid partially cleared, and a black sediment was

deposited, consisting of particles of a size separately perceptible to the unaided vision, but on trying to seize these particles between the finger they crumbled to an extremely fine powder and were exceedingly soft to the touch, and not in any way gritty, as would be expected if of an inorganic mineral or metallic nature.

On submitting this black dust to examination under the microscope, and using a high power, it became apparent that microscopic organisms were present. The spores, of a dingy brown colour, were mainly elliptical in form, though some were circular and some of an irregular pentagonal figure; where not crushed apart they were lying in heaps, or swarm-spores in close contact like clusters of bramble berries; there was occasionally to be seen a piece of, as it were, filamentous mycelium, from which the clusters or groups of sessile spores had been probably detached; the marginal border of these cells was dark, while the centre position was fairly permeable to the transmitted light, and some few seemed to possess a tiny dark nucleus; their average size was about the 1/12,500 of an inch, though many were much smaller and some few larger. On examination as an opaque object they reflected a bright yellow light in contrast to the dark background, but were not at all affected by polarised light. It will be seen that in this plate many of the elliptical sporules are arranged in catinaries, with their small ends abutting in a line with their conjugate axes, while some of these elongated members appear, on minute inspection, to consist of two circular sporules in close contact with a more or less defined septum between the individual cells.

Again, many of these spores, more especially those of elongated form, appear to be germinating by emitting a thin filament, generally, though not in all cases, from one of the narrow ends; this filament is apparently in some instances holding two or more in conjugation, though when attached to a single cell it merely resembles a flagellum.

These aerial fungi may probably have belonged to the genus Rœstitia or Æcidium, both of which genera are known to exist in the Cape, producing in the earlier stage blight in the plants they infest, and subsequently smut, mildew, or rust in the wheat and barley.

The inky appearance of the water, both of August, 1888, and of August, 1899, soon cleared after it had stood for a time in the vessel into which it had drained, and but a comparatively small amount of sediment was deposited, much less indeed than might have been expected, judging from the very sable tint which the fluid wore upon its descent from the clouds. This black water was noticed after the rainfall of the 6th August, 1899, in all water receptacles throughout Grahamstown, but I have not heard of its being detected in the surrounding district.

Such rainfalls are not without precedent in other countries. Professor Barker, in April, 1849, reported to the Royal Dublin Society two observations on a shower of black rain that had fallen around Carlow and Kilkenny and extended over an area of some 400 square miles. It is described as being uniformly black at the time it fell, resembling ordinary writing ink, but that it soon cleared after standing, and a black sediment was deposited, and that the gardeners and shepherds had had their clothes blackened when working afterwards in the clover and the fields. No microscopic examination, however, seems to have been made.

Mary Somerville, in her classic work on Physical Geography, says—"Rain dust has been most wonderfully the means of proving that the trade winds, after meeting at the Equator, cross and continue their course as upper currents. Brick-red dust has frequently fallen in large quantities on ships in the Atlantic, especially about the Cape de Verd Islands, but specimens having been examined by Professor Ehrenberg from the Cape de Verd Islands, from Malta, Genoa, Lyons, and the Tyrol, he found that they all consisted of infusoria and organisms whose habitat is South America." "There is every reason to suppose that the dust collected by Mr. Rutland in 1839, nearly midway between the African and American continents, between the 10th and 14th degrees of north latitude, consisted of American infusoria," and the same authoress, writing of the ubiquitous infusoria, says that Professor Ehrenberg had

Elliptical Sporules (magnified) in black rain.

found them in fog, rain, and snow, and in the minute dust that sometimes falls on the ocean.

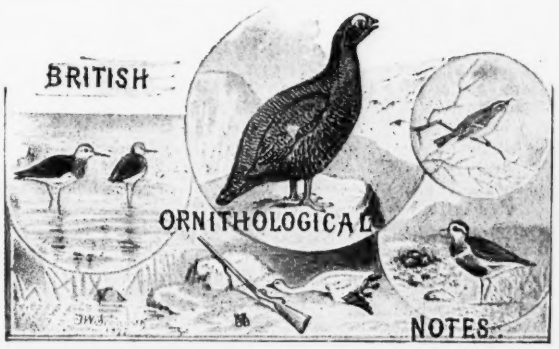
Mr. M. C. Cooke, in his work on Fungi, states that recent examinations of the common atmosphere prove the large quantity of spores that are continually suspended, and, generally, in considerable numbers. The majority of the cells were proved to be living and ready to undergo development. A suitable pabulum being exposed it was soon converted into a forest of fungoid vegetation. It has been held that the atmosphere is often highly charged with fungi spores. The experiments conducted in India have been convincing on this point ("Microscopic Examination of the Air," from the ninth Annual Report of the Sanitary Commissioners, Calcutta, 1872).

Many of these aerial fungi have been known to attack insects and use them as a basis for their parasitical growth; even the common housefly is a prey to a mouldy fungus called Sparendonema Muscae, as may be witnessed at certain seasons when our domestic companion is seen to take up his last resting place on our window panes surrounded with a white mouldy shroud.

That terrible pest, the locust, is also known to furnish a favourable medium for the cultivation of a fungoid vegetation, and valuable work is now being done in the Cape Colony by artificially sowing and

disseminating the sporules of a suitable insecticidal fungus amongst these very destructible creatures, and thereby slaying countless myriads in a very brief space of time.

The Cape mycologic flora is said to be peculiar, and can scarcely be compared with any other. From the Cape and Natal collections have been made by Zeyher Drigi and others. Humidity is known to contribute largely towards the copious production of fungi, and during protracted droughts the regions affected thereby will remain comparatively bare of fungi, but during seasons of frequent rainfalls the production of a fungoid vegetation is largely increased.



Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

THE ROBIN AND THE NIGHTINGALE.—In "Cries and Calls of Wild-Birds" I have compared a modified and very coarse rendering of the croak of the nightingale with the rattling alarm of the robin; and I instanced the croaking of two robins as illustrating a family resemblance between the cries of the two species. Another, and a remarkable, instance of this has recently been observed by me.

Early in August last I heard near my garden at Charlton Kings what I thought to be a nightingale giving its common cry, which may be written "whit-rrrr." But something in the tone of the cry attracted attention, and I was astonished to see what I felt positive was a robin, giving the notes. But I could not see the bird's breast, and therefore could not be quite sure of it. The bird soon flew away, in the manner of a robin, and was seen no more. But early in November I saw and heard in the hedge about a quarter-mile below the railway station, a robin giving the "rrrr" croak of the nightingale exactly, sometimes preceding it with one or more of the ticking sounds heard in the robin's rattling alarm. Mostly one tick only was given. Anyone, even a good observer, hearing the croak only, would at once have said that it was uttered by a nightingale. The robin is of course a near relative of the warblers, and its use of one of their most typical alarm-cries is worth recording.—CHARLES A. WITCHELL, Charlton Kings, Cheltenham.

An Observational Diary of the Habits of Nightjars (Caprimulgus Europaeus), mostly of a Sitting Pair. Notes taken at time and on Spot. By Edmund Selous. (*Zoologist*, September, 1899, pp. 388–408; November, 1899, pp. 486–505.) The very full title of this article explains its object. Mr. Selous has evidently taken a vast amount of pains in watching and recording most minutely the doings and "sayings" of this pair of Nightjars from the time the eggs were laid until the chicks hatched. To those who wish to be familiar with the domestic arrangements of the Nightjar we recommend a perusal of Mr. Selous' most original series of interviews.

Recent Observations on the Sea-fowl of the Dublin Coast. By Charles J. Patten. (*Irish Naturalist*, December, 1899, pp. 253-256.) These interesting notes chiefly relate to the occurrence of various species of waders—some of them irregular visitors to Ireland.

Microscopy.

By JOHN H. COOKE, F.L.S., F.G.S.

Bell covers, for protecting preparations from dust, may be made by cementing a small handle or cork to the centre of the convex side of watch glasses.

Mr. H. F. Moore, of the United States Fish Commission, has recently published the results of his investigations on the food of herrings. The staple diet of these fish consist of minute organisms, often of microscopic dimensions. Examinations of the stomachs of the fish showed the food to consist largely of copepods, schizopods (shrimp-like forms), amphipods (sand fleas and their allies), the embryos of gasteropods and lamellibranchs, and young fishes, often of their own kind. Many of these possess phosphorent spots, due to the presence of photo-bacteria, which enable the herring to follow their prey by night. Mr. Moore has often watched the herrings at night swimming backwards and forwards in search of their prey, "apparently screening the water, their every movement traced by a phosporescent gleam evoked perhaps by the very organisms which they are consuming."

The necessity for exercising great caution in the use of pork as food is again brought home very forcibly to us in the last report of the microscopist of the Department of Agriculture, U.S.A. In the microscopal inspection for trichinæ, 1,881,309 specimens were examined, and of these 13,325 were found to be infected. The expenses connected with this examination cost the Government 11,669 dollars.

Salicylic acid crystallized from alcohol gives, when mounted, a beautiful combination of gold and green, with shades of purple and silver points. The method of mounting is as follows:—Dissolve the acid in alcohol and allow a drop of the solution to fall on the slide. Apply heat for a few seconds, and when cool, ring the preparation with balsam and allow it to set. It may be necessary to super-impose several rings of balsam, but in each case the lower ring should have thoroughly set before another is applied. Slightly warm a cover glass and place it on the ring. The cell may then be sealed with asphaltum and finished according to taste. The preparation is most effective as a "show" slide.

In the same paper, Mr. MacDougall discusses the question of the action of the bacteria of leguminosæ, and describes the experiments of Prof. Nobbe and Dr. Hilltner in inducing nodule formation in plants by inoculation with pure cultures. To make pure cultures a fresh nodule is washed carefully, and after being dried in blotting paper, it is dropped for a moment into corrosive sublimate to kill any bacteria on the surface. It is next washed in absolute alcohol, and cut with a scalpel that has been sterilized in a flame. A platinum needle is dipped into the cut, and gelatine, previously prepared with a decoction of leguminous shoots, is streaked with it. The bacillus radicicola, being an aerobic form, requires a large surface of gelatine for propagation. A pure culture is obtained in a few days. To inoculate plants with the microbe, the bacilli are transferred to water, and a little of the mixture is sprinkled over the soil in which the plants are growing.

Living diatoms survive for days when stained with methyline blue solution (one in one hundred thousand), but the vitality of the cells wane from the moment the nucleus takes up the stain

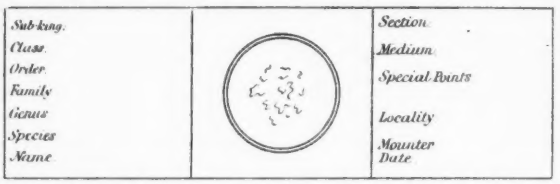
When photographing bacteria and other minute organisms, the cone of light should never be reduced by stopping down. Without a full sized cone of light, white diffraction lines will appear around the organism.

The use of mercury pellets is recommended to free slide boxes and store cabinets from mites, psoci, etc., and also to collect any particles of dust which may gain entrance. A few small pellets of mercury, placed free in the bottom, will, by the movement of the box or drawer, be caused to roll to and fro and accomplish the desired end.

XUM

In the course of some petrological investigations on the north shore of Lake Superior, Mr. A. P. Coleman discovered a new mineral, at Heron Bay, Lake Superior, which he has named *Heronite*, and which he describes at length in the *Journal of Geology*. It is a dike rock, consisting essentially of analcite, orthoclase, plagioclase, and ægyrite, the analcite having the character of a base in which the other minerals form radiating groups of crystals. The analcite clearly represents the magma left after the crystallization of the embedded minerals, and it is evident that it can be formed only from a magma highly charged with water, and therefore under pressure.

The labelling of microscopic objects, when done properly, forms a no unimportant part of the training of a microscopist. Apart from the discipline that it affords in habits of painstaking research, the systematic record that a label contains is a great time saver to the student, inasmuch as, when it is necessary to refer to the object again or to compare it with a series of objects belonging to the same genus, he is enabled to see at a glance the relation that each object bears to the others in the system of classification that is adopted, thus rendering further references to text and note books unnecessary. For these reasons the following example has much to recommend it. The labels



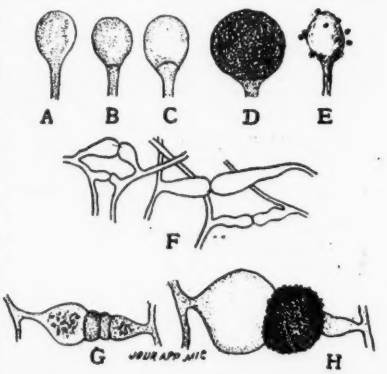
should be printed in sheets and details filled in before the labels are trimmed to size. They are placed on the slide, one on either side of the object.

Minute soft-bodied insects do not lend themselves to methods of preparation that will enable them to be kept in a condition serviceable for subsequent scientific study. Alcohol deprives them of their colour, and balsam frequently distorts, and so destroys the characteristics of venation and of jointed appendages. The method of roasting by the sudden application of intense heat has hitherto proved itself to be one of the best means of dry preservation. For Aphides the following procedure gives satisfactory results. The *living* Aphis is put on a sheet of white paper, and at the moment when it is in the desired position the paper is held over a flame, and in an instant it will be dead and will retain the attitude. Then put it, still on the paper, into an oven; or, still better, hold it over the heated tin, carefully watching the drying and moving the paper about in order to prevent it getting singed. The roasting is quickly accomplished in either way. If the paper burns brown it is a sign that caution is requisite. To pierce these brittle preparations is hazardous, and it is a better way to mount them with gum in a dry cell.

The question of the limit of resolving power of objectives is discussed by Dr. L. B. Twitchell, who points out that up to the present, Nobert's twentieth band, 225,190 lines to an inch, has never been resolved, and, theoretically, with white light only 146,543 lines per inch can be distinguished. By utilizing, however, the shorter actinic rays and a photographic plate, theoretically 193,037 lines per inch should be resolved—that is, effects beyond the possibility of ocular vision.

Mr. G. E. Stone descants, in the current issue of the *Journal of Applied Microscopy*, on the advantages of formalin as a preservative for botanical specimens. He has used formalin in his laboratory for six years for the display of the morphological, physiological, pathological and ecological characteristics of plants with most satisfactory results. The strength of the formalin solution used for preserving specimens is four parts of the forty per cent. solution to one hundred parts of water. Two to three parts to one hundred have been tried, but solutions of this strength have not proved satisfactory. Most of the specimens have been kept in a 4-100 parts solution for five years without renewing, and with the exception of a slight tendency to form a precipitate in some of the jars, they are as clear as ever. Formalin solution gives clear white colourless tissues, whereas the tissues placed in alcohol have invariably turned to a dirty brown.

In the same Journal, Prof. C. J. Chamberlain continues his admirable series of articles on methods in plant histology. He treats of the Algæ, freshwater and marine, and of the Fungi Under the Phycomycetes, he briefly discusses Mucor stolonifer, the familiar bread mould, and suggests the following method as a sure and rapid method for obtaining it:—Place a glass tumbler in a plate of water, put a slice of bread on the tumbler, and cover with a glass jar. To obtain such a series as is shown on the A-D of the figure, the material should be studied before the sporangia begin to turn black. The phase in the life-history indicated in F-H is rarely seen, and therefore the writer would be glad to hear from anyone who has met this phase, especially if the information could be accompanied by a few dry zygospores. A very satisfactory study may be made from the living material. Corrosive sublimate (four per cent.) in fifty per cent. alcohol, used hot, is recommended as a fixing agent.



A-D.—Successive stages in the development of the sporangium. E.—Columella with a few spores adhering. F-H.—Stages in the formation of the zygospore.

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

COMETS.—At present there is very little of general interest to observers as regards visible comets. Several of these objects may possibly be picked up in very large telescopes, but they have passed beyond the capacity of ordinary instruments.

The year 1899 has not been very productive of cometary discoveries, for only two new comets have been announced These were by Lewis Swift on March 3rd, and by Giacobini on September 29th. Apart from these, returns of three periodical comets have been observed, viz., that of Holmes's comet (detected by Perrine on June 10th, perihelion passage April 28th), Tuttle's comet (detected by Wolf at Heidelberg, March 5th, perihelion passage May 14th), and Tempel's comet, 1873 II. (detected by Perrine, May 6th, perihelion passage September 28th). The first periodical comet due in 1900 will be Finlay's (seen in 1886 and 1893), which should be in perihelion early in the spring, but the conditions will be unfavourable, and the comet may escape observation at this return. In the autumn of 1906 this comet should be well seen, as it will be comparatively near the earth.

HOLMES'S COMET.—Mr. R. G. Aitken, in describing (*Ast. Nach.* 3602) six observations which he obtained of this object in August and September with the 36-inch equatorial of the Lick Observatory, says "The comet was very faint—not as bright as a 14th magnitude star when best seen—and on the night of September 2nd, when the seeing was very poor, it was at times entirely invisible. It showed only feeble condensation, and the outlines were very vague."

THE SHOWER OF LEONIDS IN 1899.—A large number of observers have reported observations, but the experience in England and foreign places seems to have been general that the phenomenon presented a very feeble aspect. Occasional meteors shot from the sickle of Leo, and demonstrated that the earth was either passing near or through the swarm, but the brilliant spectacle which it was hoped would have been visible was nowhere realized. Many people who do not even make a hobby of astronomy remained up all night watching from their windows

or from commanding positions whence the display might have been viewed to the best advantage, but disappointment was almost universal. At some stations, however, it is gratifying to find it reported that meteors were tolerably numerous, and that a few fine Leonids were noticed. From these a proportion of the impromptu observers received at least a small measure of satisfaction. It may be a solace to those who saw little or nothing, when they reflect that the shower may be brilliantly visible in 1900 or 1901. In several newspapers the statement has lately been made that all chance of seeing the meteors has gone until a generation hence, when the swarm, having completed another revolution, would return in 1933. This is, however, based on a misconception, for the denser portion of the system occupies several years in passing through that region of the orbit intersected by the earth at the middle of November. We are fairly entitled to expect that either in November 1900, or 1901, the shower will be witnessed at its best, though it seems probable that in the former year it will occur during daylight in England, and 1901, when there will be no moon, apparently offers much the best prospect.

THE METEORS OF BIELA'S COMET.—There was reason to expect that as nothing of these meteors was noticed in 1898, and as the parent comet, if it still exists, passed through its perihelion some time this year, that a pretty strong shower of them might be seen on about November 23rd or 24th. They were accordingly looked for at several places, and with moderate success, for a very definite shower of Andromedids was observed. At New York, Prof. Young, at the Princeton Observatory, saw forty-two meteors on November 24th belonging to this shower, and secured photographs of several. The astronomers of the observatory at Vienna watched between early evening and moonrise on November 23rd, and counted sixty-seven shooting stars, mostly directed from the constellation Andromeda. A magnificent fireball was also seen shining in that constellation. Twelve photographs were secured. Mr. E. C. Willis reports in *Nature* of December 7th, that on November 24th he watched from 10 to 11.25, and noted fifty-two Andromedids and ten other meteors. The shower was strongest between 10 and 10.15, when twenty Andromedids were seen. At Bristol the same ill-fortune followed the observers as on November 14th and 15th, for clouds veiled the heavens on November 23rd and 24th, except for about half an hour in the early evening of November 23rd, when in a beautiful sky only two meteors were seen, and neither of these were Andromedids. It is probable that on the afternoon or early evening of November 24th the shower formed a pretty, bright, and numerous one, but we have not yet received any reports which would lead us to think that the display was in any way comparable to the imposing showers of November 27th, 1872, and 1885. The next really rich display of these meteors will probably occur on November 18th, 1905. In the spring of 1901, Jupiter will be in the region of this meteor group, and disturb it in a manner to bring its apparition six days earlier than at the present time according to the computations of Schulhof and Abelmann.

THE QUADRANTIDS.—This annual shower is sometimes rather striking, and quite as rich as the Perseids, though it has been comparatively seldom observed. It should be looked for on the early evening of January 2nd, and morning of January 3rd. The radiant is at 230° + 53°; the meteors are pretty bright, of moderate velocity, and traverse long paths.

THE FACE OF THE SKY FOR JANUARY.

By A. FOWLER, F.R.A.S.

THE SUN.—On the 1st the sun rises at 8.8 and sets at 4.0; on the 31st he rises at 7.42 and sets at 4.46. The sun is at its least distance from the earth at 6 a.m. on the 2nd, the apparent diameter then being at its maximum, 32' 35".08; the horizontal parallax is then 9".00. Few sunspots are to be expected.

THE MOON.—The moon will be new on the 1st at 1.52 P.M., will enter first quarter on the 8th at 5.40 A.M., will be full on the 15th at 7.8 P.M., will enter last quarter on the 23rd at 11.53 P.M., and will be again new on the 31st at 1.27 A.M. The following are the most conveniently observable occultations during the month:—

Date.	Name.	Magnitude.	Disappearance.			Reappearance.		
			Time.	Angle from N.	Angle from V.	Time.	Angle from N.	Angle from V.
Jan. 6	19 Piscium	5·2	7.12 P.M.	91°	63°	8.10 P.M.	215°	182°
,, 10	τ^2 Arietis	5·2	7.1 P.M.	33	49	7.59 P.M.	295	295
,, 10	65 Arietis	5·6	7.55 P.M.	45	47	9.1 P.M.	288	271
,, 11	κ^1 Tauri	4·6	10.27 P.M.	115	90	11.34 P.M.	241	205
,, 11	κ^2 Tauri	5·5	10.40 P.M.	143	115	11.23 P.M.	213	178

THE PLANETS.—Mercury is a morning star throughout the month, but is not well placed for observation in our latitudes on account of his great southerly declination.

Venus is an evening star, setting on the 1st about 2 hours after the sun, and on the 31st nearly 3 hours after the sun. The planet will be found low down, south of west, soon after sunset. At the middle of the month nearly nine-tenths of the disc will be illuminated.

Mars will be in conjunction with the sun on the 16th, and cannot be observed this month.

Jupiter is a morning star, rising shortly after 4 A.M., at the middle of the month, his polar diameter then being 30".6. The movement of the planet is direct, in the northern part of Scorpio.

Saturn is a morning star but too near the sun for easy observation, rising just before half-past six at the middle of the month.

Uranus is also a morning star, rising about 5 A.M. at the middle of the month.

Neptune, in Taurus, may be seen almost all night. His movement is westerly. He is in the Milky Way, almost midway between Žeta Tauri and 132 Tauri.

THE STARS.—About 9 P.M. at the middle of the month, Ursa Major will be in the north-east, Leo and Cancer towards the east, Gemini high up, and Canis Minor lower in the south-east, Auriga and Perseus nearly overhead, Orion and Taurus nearly in the south, Aries and Cetus towards the south-west, Pegasus and Andromeda in the west, and Cygnus in the north-west.

Convenient minima of Algol will occur on the 4th at 7.33 P.M., on the 24th at 9.15 P.M., and on the 27th at 6.4 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of December Problems.
(C. D. Locock.)

No. 1.

1. Kt to K7, and mates next move.

No. 2.

1. B to Kt2, and mates next move.

CORRECT SOLUTIONS of both problems received from E. A. Servante, H. S. Brandreth, W. de P. Crousaz, W. d'A. Barnard, G. F. Todd, J. Baddeley, A. E. Whitehouse, G. C. (Teddington), K. W., H. Le Jeune.

Of No. 2 only, from Alpha, G. A. Forde (capt.).

J. T. BLAKEMORE.—Many thanks for your prompt response, the two problems appear below.

XUM

J. NEVILLE.—Very glad to receive your appreciative letter.

G. F. TODD.—Your suggested key 1. Kt to Kt5 to the four-mover certainly comes very near. For instance neither 1. . . . P × P nor 1. . . . B to Kt5 nor 1. . . . K to Q4 are valid defences. There is nothing left therefore except 1. . . . B × Kt.

J. O. NEUMANN.—In No. 1, after 1. B to KKt7 there is no mate, whatever Black reply. In No. 2, 1. B to K7 is answered by K to K4 or Bishop moves. By exchanging the column of letters for the row of figures your notation would become the ordinary German notation.

ALPHA, G. A. FORDE.—If 1. Kt to KR4, P to Q4. Hence the Black Pawn at KKt5.

B. G. LAWS.—Problem withdrawn as requested. The coincidence which prevents its publication is as curious as it is unfortunate for us.

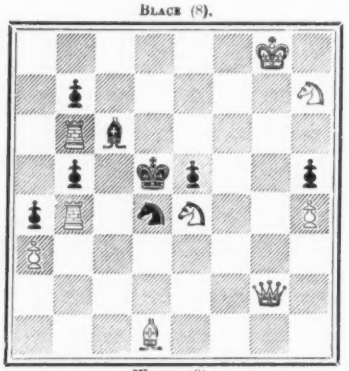
J. BADDELEY.—We quite agree with you in principle: but how about a fifteen-move problem? Few players but Mr. Blackburne could manage this from the diagram alone: and yet these long problems, sui-mate or otherwise, frequently contain the most beautiful combinations. Moreover, if the composer moves the pieces, may not a mere solver do likewise without reproach?

PROBLEMS.

By J. T. Blakemore.

No. 1.

BLACK (8).

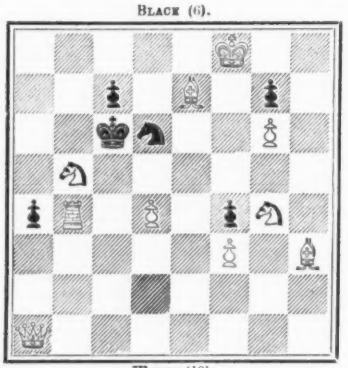


WHITE (9).

White mates in two moves.

No. 2.

BLACK (6).



WHITE (10).

White mates in two moves.

Mr. Blackburne's Games at Chess. Edited by P. Anderson Graham. (Longmans, Green & Co.)

Some two or three years ago Dr. Tarrasch published a selection of 300 of his games. Mr. Blackburne has now followed suit with this handsomely bound volume, which contains more than 400 of his games, selected, annotated and arranged by himself. Mr. Blackburne has undoubtedly been, for the last thirty years, the most prominent of English chess-players: the present volume illustrates his skill in all departments of the game. The games are divided into four sections, viz.:—

(1) Match, Tournament, and Consultation Games. In this section the games are grouped under the various openings, the arrangement in other respects being chronological.

(2) Games played off-hand, simultaneously, or at odds.

(3) Endings from Actual Play.

(4) Games played Blindfold. This last section is prefaced by a short history of blindfold chess contributed by the Editor, who is also responsible for the interesting biography of Mr. Blackburne at the beginning of the book. The annotations to the games are brief and descriptive rather than analytical. Since the editorial days of Zukertort and Steinitz the analytical method of annotation has gone out of fashion. Mr. Blackburne prefaces each opening with a brief resume of its characteristic features. We may perhaps take exception to his description of the Ruy Lopez as a dull opening "leading to no attack." This seems a little hard on the favourite opening of Mackenzie and Zukertort, to say nothing of Morphy and Anderssen. Twenty-eight of Mr. Blackburne's excellent problems in three and four moves conclude the volume, which is published at 7s. 6d. net. It should certainly have a large sale.

CHESS INTELLIGENCE.

The Anglo-American cable match will take place during March. The British team will undergo some alterations. Mr. Locock has retired from active chess. Mr. Lawrence has been singularly unfortunate on both the occasions on which he has represented his country; but as he has already scored six successive victories in the City of London Championship tourney, and has therefore again the best chance of winning that competition, he could hardly be left out of any representative team. Messrs. W. Ward, R. Loman, and Jacobs are also making good scores.

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